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INDEX TO AUTHORS

The following papers appeared in the last issue of Fishery Technology

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Spiny Lobsters and Their Fishing Techniques

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Scores of publications on spiny lobsters and their fishing techniques are available from various parts of the world. A variety of fishing gears which vary in design and operation are employed for exploiting lobsters. A review of the work carried out on spiny lobsters with special reference to their distribution, fishing gear, fishing methods, baits and crafts in India, Sri Lanka, United States, Australia, South Africa, United Kingdom, Ireland and Portugal based on selected literature are considered and discussed.

The present knowledge on various aspects of spiny lobster fishery is mainly from Australia, United Kingdom, United States of America, South Africa, Japan, France, New Zealand and India. Scores of research publications are available, out of which an exhaustive and indexed bibliography on the spiny lobsters (Palinuridae) edited by Kanciruk & Herrnkind (1976) and annotated bibliographies on spiny lobsters by Sims (1966) and Smolowitz (1978) deserve special mention. Mc Koy (1979) has published an annotated bibliography exclusively on the New Zealand rock lobster *Jasus edwardsii*. However literature pertaining to different fishing gears and methods employed in Indian waters are few.

Distribution

Spiny lobsters are found in warmer seas throughout the world. They are variously known as rock lobster, spiny lobster, sea craw fish, langouste and langosta (Smith, 1958). In India, there are about six species occurring in the submerged rocky patches along the coast. The species in the order of commercial importance are *Panulirus homarus* (Linnaeus), *Panulirus polyphagus* (Herbst), *Panulirus ornatus* (Fabricus), *Panulirus versicolor* (Latrielle), *Panulirus penicillatus* (Olivier) and *Panulirus longipes* (Milne Edwards). *Puerulus sewelli* (Ramdan) and *Palinustus mossambicus* (Barnard) are two deep sea lobsters recorded from India (George, 1967; 1973; George & George, 1967).

Six species of Panulirus are found in seas around Sri Lanka namely *Panulirus dasypus, P. versicolor, Panulirus japonicus, P. penicillatus, P. ornatus* and *P. polyphagus*. All except *P. polyphagus* are uniformly distributed in reefs and rocky areas around the island, with *P. dasypus* dominant on the west coast, *P. ornatus* in the north and *P. versicolor* in the east (De Bruin, 1962).

Nine species are found in Australia (George, 1966). They are *P. versicolor* (Latrielle), *P. homarus* (Linnaeus), *Jasus verreauxi* (Milne Edwards), *Panulirus cygnus* (George), *P. longipes* (Milne Edwards), *P. penicillatus* (Olivier), *P. ornatus* (Fabricus), *P. polyphagus* (Herbst), and *Jasus lalandei* (Milne Edwards). Four of them *P. cygnus* (western rock lobster) *Jasus lalandei* (southern rock lobster) *Jasus verreauxi* (eastern rock lobster) and *P. ornatus* (tropical rock lobster) are fished commercially. Western lobsters are confined to Western Australia, where they are caught over an area of about 20,720 sq. km within the 45 fathom line extending from Bunbury to Shark Bay and further along the reefs fringing the Houtman Abrolhos Islands, off Geraldton. The tropical rock lobsters of Australia are found in North Australia and in Papua New Guinea and are commercially fished by divers from Thursday Island in Torres Strait. As it will not enter the conventional baited pots, it is speared and caught by hands (Hughes, 1971).

The major catch of lobsters in New Zealand is constituted by *Jasus edwardsii* (Hutton) and *J. verreauxi* (Milne Edwards). From Phillippines three species of Puerulus, namely, *Puerulus sewelli, Puerulus ortman* and *Puerulus angulatus* are recorded. *P.*

sewelli is also reported from Gulf of Aden, Arabian sea off Travancore, North West of Colombo and Gulf of Mannar (Holthuis, 1965). *Linuparus trigonus* (Von Seibold) is now reported from Philippines (Holthuis, 1965) and another species *Linuparus white* from South China Seas (Bruce, 1965). The important species occurring in Japan is *P. japonicus* (Von Seibold). The South Californian market lobsters are *Panulirus interruptus* (Randall) and *Panulirus inflatus* (Bouvier) and are also present to a limited extent on the west coast of Mexico and around Hawaiian Island. The form usually found in the Hawaiian market however is *P. japonicus*. The other species of Pacific lobsters include *Panulirus gracilis* caught in Gulf of Panama (Smith, 1958).

In Indian Ocean, commercial fishery is dependent on *P. ornatus* and *P. polyphagus*. The South African genera are *Jasus, Palinurus* and *Panulirus* (Silas, 1967). *Jasus lalandei* forms the bulk of South African fishery, where it is known as Keef or Cape craw fish. Another species of spiny lobster from South Africa is *Palinurus delagoae* (Berry, 1973). From Mozambique *Panulirus gilchristi, P. ornatus, P. longipes* and *P. versicolor* are reported. What is probably a subspecies of *J. lalandei* supports an important fishery off the coast of Chile (Smith, 1958). There is a seasonal fishery for *J. lalandei* in St. Pauls and New Amsterdam Islands where at present the catch is limited to 200 tonnes of lobster per year. Jasus is the only genera of Palinuridae known so far to occur around St. Pauls and New Amsterdam Islands (Silas, 1967).

Palinurus rissonni (Desmarst) is caught on the west coast of Africa and sold in France as the "Royal Langouste." A Mediterranean species *Palinurus elephas* (Fabricus) is caught from the French coast, whose distribution extends north to Great Britain (Smith, 1958), but the important one in British and Irish waters is *Palinurus vulgaris* (Forsyth, 1946). The common Carribbean species *Panulirus argus* (Latrielle) is found in the Western Atlantic from Rio-de-Janeiro, Brazil to Beaufort, North Carolina and Bermuda. Within these geographical limits, the Carribbean spiny lobster is caught in sufficient quantity only in Florida, Bahamas, Cuba and British Honduras. Along the coast of Brazil the common form of spiny lobster is *Panulirus laevicauda* (Latrielle). Small numbers of related species are occasionally found in commercial catches of Western Atlantic and Bermuda. They are *Panulirus guttatus, Palinustus truncatus, Justitia longimana* and *Palinurellus gundlachi* (Smith, 1958).

Fishing gear and methods

A wide variety of fishing gears are employed for catching lobsters. They vary in design, fabrication and mode of operation from place to place. Hand picking to trawling are employed in various parts of the world. Lobster traps however seem to be the well known and conventional fishing tackle extensively employed.

Traps

The terms 'traps and pots' are used interchangeably. Some of the primitive traps, invented by the ancient men can still be seen in many parts of the world (Job & Pantulu, 1953). Trap is a highly versatile fishing gear; its dexterous operation enables several scattered areas to be worked simultaneously. Even today wicker-work baskets used for fish, crustaceans and even snails (whelks) are spread all over the world especially for fisheries in river or off the seashore (von Brandt, 1972).

Hornell (1950) considers traps as the earliest form of fishing gear used in the Orients, which have been later introduced to several other parts of world. The findings of Arocha (1964) support this assumption. Dow (1964) is of opinion that the probable forerunner of traps is the creels of Northern Europe and British Islands. In Canada lobster trap is supposed to have come into operation by about 1870 (Levett, 1965).

India

The indigenous traps used in south west coast of India for catching lobsters are generally termed as "Colachal type", the shape of which is described as 'heart shaped' or as 'arrow heads' by different authors. It is collapsible and consists of three parts– floor, top and sides with a removable entry funnel in front. The different parts are normally laced together with vegetable fibres. Miyamoto & Shariff (1961)

described these traps and their operation. Presently the operation of traps in India is mostly confined to 8–12 m in depth. Similar traps are also used in other parts of the world. In Panama, the woven reed trap similar to the Indian lobster trap is in use (Pease, 1965).

Sri Lanka

Methods employed by Sri Lankan fishermen are described by De Bruin (1960). Gear efficiency tests were conducted in Ceylon, with 'Scottish creel', the 'Canadian parlour and bedroom' and 'Cornish inkwell' traps. A collapsible Canadian type made of steel and hemp netting was developed later, and found to be efficient and convenient.

United States

The earliest recorded instance of fishermen operating a string of lobster pots commercially was in 1870 (Levett, 1965). In United States, the fishermen have gradually settled to two types of pots, semicylindrical and the rectangular. Seasoned wood of oak, spruce and hem-lock are favoured for the construction.

Semicylindrical lobster pot is still the most popular in State of Maine. It measures 80 x 68 x 45 cm and has a short chamber and a longer 'parlour'. The completed traps are weighted with 2 to 4 building bricks. The buoy line is attached at the corner of the chamber end (Firth, 1944).

The rectangular pot is of more recent origin than the half round type. The absence of curved surfaces makes the rectangular trap more rugged and easy to repair. The traps thus made stack better. A typical pot measures 80 x 65 x 40 cm at the base with 55 cm width at top (all outside measurements). Originally these traps had only one opening at the side, but the present practice is to have one opening each at both the sides (Firth, 1944). In addition, the traps called 'parlour trap' and 'double headed trap' with six different versions of each are in vogue. The parlour trap is generally preferred from Kittery East Waters to Cape Split while the 'double header' is in use from Cape Split to State's eastern extremities.

'Igloo'—a new type of dome shaped plastic trap with a vertical entry has an effective life of 8 to 10 years. The trap is very stable. 'Igloo' traps comes in 4 sections, the base has a mild-steel ring with a tow eye. Each pot can be nested separately during transport and can be baited and assembled in seconds. The trap weighs 9 to 9.5 kg in water and 11 kg in air (Anon 1965).

Australia

Lobster pots of Australia are described by Hughes (1971). There are 4 types in commercial use with the same catching techniques. Pot dimensions differ from area to area with the species. Beehive pots are extensively used. The frame may be woven with cane, ti-tree or similar sticks and covered with wire netting. It has a basal diameter of 90 to 105 cm, height 62 to 72 cm, diameter of the neck 18–30 cm, depth of the neck 15–21 cm and width of the cane apron 8–12 cm.

The stick pot construction is popular in Western Australia. The frame consists of 19–25 heavy, galvanised wire of 5 mm diameter and is closely woven with 10 mm diameter cane. Ballast is placed inside to sink the pots and to hold them to the sea bed.

Wire pots are more popular in Southern Australia, whose frames are fabricated out of 10 mm mild steel rod with horizontal stiffening with metal rings welded to 8 — 12 vertical frames. A covering of heavy galvanised wire netting is used round the circumference of the pot. It is also a common practice to use moulded plastic neck and apron. Ballast is seldom used, as the trap itself is heavy.

Wooden batten pots are used in shallow waters of Western Australia. These pots are constructed with wood or have a welded strap steel bottom with wooden sides and top. The neck is made of either wood or plastic. One end of the pot can be removed for baiting and removal of catch. Ballast is necessary for all wooden pots. It has a length of 80 to 85 cm, width (base) 70 to 80 cm, height 38 cm, width (top) 30 to 52 cm, neck 18 x 18 cm, depth of neck 15 to 20 cm. Winstanley (1979) indicates that dual purpose traps for crab-lobster fishing would be more rewarding.

Alec White of Aden while studying the Western Australian cray fish industry, obtained a pot from the Western Australian Fisheries Department. The pot is of wicker work construction and weighs only few kg. The top section is laced to the sides, but only loosely along the edge opposite the entrance (Anon, 1963).

Japan

Besides the conventional traps the latest one used in Japan is a collapsible one made with flexible polythene tubing and synthetic fibre netting. The diameter of its circular base is 97.5 cm, mesh size of plastic covered wire netting 2.5 cm, diameter of frame tubes 1.8 cm, and netting of 5 cm Kuralon. There are two opposite entrances with an outer diameter of 23 cm and inner diameter of 15 cm. The length of entrance is 16.5 cm. Size in collapsible state is 12 cm high and in rigged state 67.5 cm high (Temple, 1964).

South Africa

South African lobster traps are identical to the American parlour pots and are constructed with a metal frame work of truncated pyramid shape with hexagonal base. The trap measures 105 cm across the base and is 22.5 cm in height and weighs less than 4.5 kg and collapses to a thickness of 2.5 cm enabling boats to carry large numbers (Anon 1960).

Angot (1951) gives a brief description of the traps used which is closely akin to the type used along the French coast and Gulf of Maine. It is semicylindrical, with a rectangular basal plate and with two openings along the upper median line. The flat bottom enables the trap to rest properly on irregular bottom. It is also reported that 50–70 kg of lobsters are caught per day, and each boat uses about 20 to 50 traps (Silas, 1967).

England

The pots used in England are the 'cornish pot' and the 'creel' or 'creeve.' Cornish pots are bulky, 60 cm or more in diameter, beautifully woven in willow with a top entrance or spout varying from 12.5 to 20 cm.

Cornish spherical traps made of tougher wood dates back to the early 17th century. Stones or bricks were used as ballast. Such types are rare in Scotland (Forsyth, 1946). There are several designs of parlour pots but the one most favoured is a fore bowed east coast pot with opposing spouts in two of the divisions. One entrance is at one side and woven to the central bow is another funnel leading to a chamber at the opposite end (Forsyth, 1946).

In single eyed creels, the base measure 50 x 37.5 cm, the roof is slatted and the netting is cut from otter trawl and stitched to the frame. The height is roughly 30 cm (Forsyth, 1946).

The frame work of metal pots consists of 3 mm rod covered by 3 mm wire of meshes 1.6 cm. There are oval, top and side spouts, scaling 25 x 20 cm with a door at one end. The spouts are reduced to about 5 cm at the inner ends and are fitted with pigeon traps and counter balanced with a piece of lead to keep them in down position (O′ Farrel, 1966). Pots of French pattern are seen on the south coast of England. It is a cylinder of wooden laths, closed at each end by netting or laths, with a single opening half way long. A pot made of rabbit wire supported on iron frames and triangular in section is found at Babbacombe. On the Cornish coast, modifications of Cornish pot made of wire are often used (Davis, 1958).

An ingenious type of French pot is reported from Beaumaris. It is cylindrical and the outer supporting hoops are the rims of bicycle wheels joined longitudinally with broom sticks and opening of the funnels are supported by the rim of small perambulator wheels (Davis, 1958). There are more types of lobster pots used on Welsh coast than in any coast in British Isles. There are three types, (a) Cornish ink-well type with eye at the top (b) Scottish creel, cottage shaped, with an entrance on either side and (c) barrel pots. (Simpson, 1959). Folding pots are being used in Broad Stair and this helps in saving deck space (Anon 1962).

Norwegian 'Venor pot' has also been tried here. It consists of upper and lower halves which are readily assembled or taken apart by a twist of the upper half. During fishing

operations this can be facilitated by the use of two pins fixed in the boat to steady the lower half. The funnel of the pot is of polished plastic and is moulded integral with the frame. Pot is 39 cm high and has a diameter of 50 cm at the centre (Burgess, 1963).

Ireland

The Irish craw fish industry centers mainly on the use of French barrel pots introduced into Ireland in 1947 (Culley & Driver 1972). Recently lobster pot industry is developed in Ireland based on a new North American type. The difference between the new and the traditional type off Irish coast is that it has a double trap—a kitchen and a parlour (Anon 1966).

The ideal design of lobster pot in Ireland is the 'round turret lobster pot' designed by an Irish fisherman, Thomas G. Pyne. This has the entrance at the top and is made of heavy gauge galvanised steel wire on treated steel frame. Pot weights 3.2 kg and is 140 cm in circumference, 42 cm high with 22 cm diameter plastic entrance with 'V' cuts at the bottom to ensure that lobsters do not escape. It combines light weight, low cost, escape proofness, compactness and strength (Anon 1970).

France

Plastic moulded lobster pot of France is called 'Kavel lobster pot.' Designed along the lines of hexagonal French 'Casier', the pots are made in six separate parts which can be quickly and easily assembled or dismantled with the aid of simple tool. The pot is 76 cm long, 58 cm wide and 45 cm deep with an inlet neck of 25 cm diameter at its widest part. When assembled, the pot weighs 4 kg and about 9 kg of ballast must be provided to it (Smith, 1969).

Portugal

Portuguese traps for spiny lobsters are made of wood and wire and is almost drum shaped, wire netting mounted on both the ends and the wooden or bamboo slats lengthwise (von Brandt, 1972).

Pot tippers

For the efficient and easy handling of lobster traps under operation, mechanised pot tippers are used as standard equipment in most West Australian cray boats, even though fishermen of eastern states are slow to adopt them. This equipment in its modified version has become part of a lobster fishermen's gear in Japan, America, Canada, South Africa and Norway. It is known as Fremantle cray pot tipper (Hughes, 1966).

Though simple in mechanism, these devices are great labour savers. Used to set and retrieve pots, pot tipper is a hinged platform or a see-saw with a roller across the inboard or upper end. Lobster pot haulers are almost invariably constructed from rear axle assembly of car or a light truck. When the pots are being retrieved, the bouy line is picked up first and brought about. It is lead to the hauling winch over a roller, situated between the two vertical guides on the tipper. The bouy line is hauled, until the pot reaches the roller, the tipper swings upwards and the pot slides inboard and comes to rest on the guide rails. The hinge position can be varied to change the angle of the tipper to the side of the hull. The roller position regulates the length of the leverage from the pivot point (Anon 1973).

Other than the conventional traps, there are innumerable methods by which lobsters can be caught successfully.

Anchor hook

The method of fishing with anchor hooks for lobsters in south west coast of India has been described by Miyamoto & Shariff (1961). Anchor hook consists of 3 parts—the hook, brass wire and cotton line. The hook proper is shaped like that of a small grapnel anchor with 6 sharp arms of 10 to 12 cm made of cast iron. The brass wire used for the snood part is 3 fathoms long and 16 gauge in thickness. Cotton line used for lowering the hooks to the required depth is 20 counts, 36 threads, 3 ply, or 10 counts, 21 threads, 3 ply. Mussel (*Perna* sp.) is used as bait and fishing is generally done during night. The baited lures are lowered on reaching the fishing ground and when the bite of the lobster is felt, the hook is pulled fiercely, when the lobster gets hooked. The lobsters thus caught are necessarily wounded or mutilated.

Scoop net

In India fishing for lobsters with scoop net was successful and prevalent when the lobster population was very dense. Here, a lure line either baited or unbaited is lowered to the area populated by lobsters and slowly pulled up until the lobsters follow the line and reach very close to the fishing craft. Once they are near the surface they are scooped up by a scoop net (Miyamoto & Shariff, 1961). The gear used in some parts of Sri Lanka such as Galle Harbour is very similar to the device employed for the capture of crab, *Scylla serrata* and consists of a heavy iron ring about 75 cm in diameter carrying a conical net. A rope is stretched across the diameter of the ring, to which at the middle the bait is fixed. Three strands of the rope are attached to the ring at three points on the circumference. The free ends of these strands are joined to a single rope which is pulled up for hauling the gear (De Bruin 1960).

Bottom set-net

Bottom set nets generally used for catching lobsters in some parts of India, are usually made from old webbing re-rigged as bottom set gill nets. Each piece is 18 m in length and 3 m in breadth. Mesh size varies from 8 to 15 cm. Each unit consists of 6 to 12 such pieces. 5 to 9 floats of wood or plastic are attached to each piece on the head rope. The nets are lowered and set at the bottom with a marker float and long buoy line at the beginning of the first piece and at the end of last piece. The nets are so laid, that they encircle an entire rocky patch and the lobsters generally get entangled in the webbing (Balasubramanyan *et al.*, 1960).

Experimental rock lobster fishing operations were conducted during 1958–59 along the south west coast of India with newly designed bottom set gill nets. This was repeated with a slightly modified design during 1959–'60. As the fishing operations proved successful, the design became popular among the fishermen thereafter (Balasubramanyan *et al.*, 1961). In the coast of Spanish Sahara also fishermen use bottom set nets for lobsters (Anon 1967). De Bruin (1960) has also reported the use of old webbings as bottom set nets for catching spiny lobsters in Sri Lanka.

Trawling

Commercial trawling for lobsters is employed in Norway, Sweden and France. Stray catches of lobsters are obtained during trawling for bottom fishes in Indian waters especially along the east coast of India. De Bruin (1960) has reported catches in Granton trawl at a depth of 20 fathoms in Sri Lanka.

Fishermen of United States have dragged for lobsters since mid 1950's especially on the banks of north eastern United States. The boats and crew are larger than in inshore fishery and they exploit different stocks under different conditions. The U. S. offshore fleet is switching from trawl to trap fishery, which indicate that as stock is exploited near to maximum sustainable yield, trapping is more efficient than trawling (De Wolf, 1974). Offshore lobsters are harvested either by otter trawls that are specifically rigged for catching lobsters or to catch lobsters incidentally while fishing for ground fish (Doliber, 1973). Trawling is done on aggregation of migratory lobsters, in the middle of Gulf of Papua during October and November as reported by Moore & Mac Farlane (1980)—the first trawl catch being in 1973.

Hoop net

Introduction of hoop nets marked the beginning of today's systematic fishery of lobsters in Maine, America's northern most Atlantic state. Hoop net consists of a circular piece of fish net, supported by an iron hoop up to 1.8 m in diameter in such a way that the net sags in centre. The bait is tied to the centre of the net which is then lowered to the sea bottom by means of a rope line and bridle attached to the hoop. The hoop is hauled at a fast steady pace so that the craw fish attached to the bait will be held in the sagging centre of the net. This method of fishing is not widely used in western Atlantic, but is occasionally carried out from anchored boats off Florida Keys. South African industry however relies entirely upon this method. The nets are set out in rows upto 25 fathom deep and are buoyed in a manner similar to traps (Smith, 1958).

During experiments conducted in England using 'Scoop' (hoop traps) and creels (wooden traps) it was found that 'scoops' were

more efficient than creels when the population of lobsters was dense and that the efficiency increased with increasing concentration of lobsters (Thomas, 1953).

Bulley net

Bulley net is a small hoop net of about 45 cm in diameter and depth with 3 cm mesh. The hoop is fastened at right angles to a long pole. A pole carrying a stiff wire probe is used to force the lobsters from the hiding and then caught by the hoop net (Smith, 1958). In India too bulley nets called 'Gadas' and wall seine nets are used in Bombay coast for catching spiny lobsters (Jones, 1967).

Trammel net

Trammel nets made of nylon have caught considerable number of lobsters in Haiti. They were set at the bottom primarily for experimental scale fishing (Smith, 1958). A similar experience with tangled nets is reported from west Africa (Smith, 1958). Trammel nets are used in Bombay coast also for catching lobsters (Jones, 1967). In Mediterranean, spiny lobsters are mainly caught in trammels and bottom set gill nets (O'Farrel, 1966).

Grains, spears and grabs

Grains, spears and grabs are seldom used in commercial fishing but are fairly common in Caribbean waters. Lobsters pierced with spears or two pronged grains are necessarily damaged. Grabs are long paired poles hinged near the bottom so as to act as tongs but they are not used very frequently (Smith, 1958). The use of gaff hooks by divers for spearing the spiny lobsters has become prevalent in some parts of India. In the grounds where the lobster stock is highly scattered and sparse, fishermen wearing diving masks resort to naked diving and with the help of gaff hooks, some times attached to long poles pierce the lobsters even while they are in the burrows. While referring to the lobster industry in Clark's Harbour, Nickerson (1937) deals with some of the early catching methods of lobsters in America. "One way of catching lobsters in very shallow water was to throw bait over and as it lay on the botttom they would come up for it and be hooked up with long gaffs".

Ice can and gasoline drum traps are made of discarded metal ice moulds and consists of light steel rectangular tank about 120 cm deep and 23/75 cm in section. The trap is prepared by crushing in the rim of the opening in such a way as to have two openings of sufficient size to admit the spiny lobsters. Small holes are punched on the sides in order to allow ready egress of water. The can trap does not need a bait, since the lobsters enter it in much the same way as they enter the rocky crevices in search of shelter (Smith, 1958).

Raft fishing

Crude rafts are prepared of drift wood and sunk to the bottom where spiny lobsters accumulate. Then the raft is surrounded by old pieces of netting and the lobsters are caught by hand or with bully nets, or become entangled in the net when they rush to escape. Since this method takes advantage of the lobsters' habit of retiring to shelters during day, bait is unnecessary (Smith, 1958).

George (1967 a) has reported on the use of cast nets by some fishermen from canoes in north Malabar coast for catching spiny lobsters.

Baits

The role of bait in a method of fishing where the principle involved is that of luring the organism, is of utmost importance. It looks as though, exclusive study on baits used in lobster fishing in India has not been made in detail. Miyamoto & Shariff (1961) have referred to only one type of bait used by the Indian lobster fishermen, namely the sea-mussel (*Perna* sp.). About 100 to 200 mussels are put as bait in the traps in live condition. Occasionally sea-urchins are also used as bait. This is also available in the rocky bottoms and is picked up by divers. After the spines are scrapped off, the shell and the internal organs are beaten to pulp and then spread inside the trap. There are about 30 variety of baits available to the fishermen in Australia such as sheep-head, fish heads whole fish and the like. Sometimes fish heads are imported from overseas and Eastern States. Bait is the biggest single item of expenditure to the fishermen in Western Australia (Hughes, 1971). A canned product with fish offal as base has

been developed in Australia, the use of which appears to be satisfactory (Gates, 1961).

In United States bait consists of low priced fish or salted fish, trimmings from nearby canneries, spoiled fish or fish frames from which the fillets have been removed. Here again the cost of the bait is an important operating expenditure as an average of 700 g is required each time. Oily fish, either fresh or salted or partially decomposed seems to possess the greatest attraction for lobsters. When the bait materials are soft or decomposed, they are chopped up and placed in bait bags treated with coal tar (Firth, 1944). It is reported that during exploratory fishing conducted for spiny lobsters, sand lobsters and scallops in Panama, experiments were also made to determine whether or not lobsters showed any significant preference to the variety of locally caught baits. According to Pease (1965) all species were of equal efficiency as long as they were fresh, but putrid bait appeared to be less attractive. Davis (1958) records that lobsters are dirty feeders and are usually caught with any fish remains and are particularly fond of stale wrasse.

According to Forsyth (1946) 'stale bait for lobsters and fresh bait for crabs' is the advice of fishermen. Fish heads of wrasse, pollack, flounder, eels and other fish of low market value also may be obtained. If the fish used are salted lightly and kept in barrels for a few months a strong smell of fish oil is emitted and this forms a most attractive lure for lobster. Offal usually thrown away by local fish mongers may also be utilised. Skinned and salted sea birds are used in some places. The bait or bait bag is placed on the top of a stone. Some fishermen place the bait in a small box of 18x13x10cm, the sides of which are profusely perforated. In Sri Lanka, baits used are the cheapest available, mainly fish heads of *Lutianus rivulatus, Lethrinus rostratum, Epinepheles tauvina* and *Drepane punctata* (De Bruin, 1960). During some experiments in Maldive Island baits like chunks of *Caranx stellatus* and mantles and muscles of *Tridacna* were tried without much success (Jonklass 1967). The fishermen of New Amsterdam Islands have found that the flesh of the 'Blue fish' *(Chirodactylus macropterus)* attracts more lobsters to the traps than any other bait (Silas, 1967).

Fishing crafts

The type of craft used in operating lobster traps from south west coast of India is the 4 logged boat catamaran. It is about 6.3 m in length and 0.6 m in width and is usually constructed of very light buoyant wood *(Albizzia* sp*)*. The propulsion is by sails usually and at times by oars. Bottom set nets used for lobster fishing are operated from catamaran as well as from small dug out canoes called 'Vallams.' However trawl nets in which lobsters some times form the incidental catch are operated from mechanised trawlers.

Boats used in Australia are fully mechanised and vary in size and design, according to the area in which they operate. Their length can be from less than 7.6 to 24.4 m and some of these boats are even fitted with echosounders. Some have a dual role in catching such as shark/lobster and lobster/prawns, depending on the prevailing season. In west Australia high powered boat with planing hulls are popular and are capable of developing more than 20 knots speed. These scooter boats with planing hulls are designed to operate among reefs. Dual purpose boats are mostly larger vessels with displacement type of hulls. They operate in south Australia, Victoria and Tasmania (Hughes, 1971).

Steel prawn trawlers of 30 m size have operated with increasing efficiency during the period of lobster migration across the Gulf of Papua in Australia. Daru lobster fishermen on the western side of Gulf of Papua still commonly dive from traditional sailing dug out canoes (Moore & Mac Farlane, 1980). In England creels are worked from small boats upto about 15 m length with a wheel house well forward to allow plenty of space aft for handling the creels. Small boats 6 to 12 m in length are usually used to work 8 to 10 creels. A motorised catamaran with a speed of 20 knots or more has been built on English south coast for lobster fishing from island of Islay, western Scotland. This 11.1 m catamaran can carry 300 pots aboard (Anon 1977). A London firm which specialises in small GRP trihedral hulled boats has released a popular fast creeling/potting boat. This is proving to be particularly suitable for catching 'scampi' which inhabits the

muddy bottoms (Anon 1980). Gasoline powered boats 4.2 to 7.5 m long are also used in this fishery. Sometimes they are tended in dories and if required they are towed by power boats (Firth, 1944).

In Sri Lanka out rigger canoe is the craft commonly used by lobster fishermen (De Bruin, 1960). In some European and American countries specially designed vessels are built, capable of spending upto 6 months away, storing the catch all the while. Even vessels of 250 tonnage is considered small in this context. While fishing for lobsters off Spanish Sahara, mother ships are used which anchors at a safe distance and men go out to set their net using two 7.5 m sea going launches (Anon 1967). Spiny lobster fleet that fish out of Cape Town, South Africa is composed of 15 m to 18.5 m long wooden vessels that resemble New England dragger in profile. Each vessel carries 4 to 6 wooden dinghies and a crew of 16 men (Anon, 1963a).

In United States fast sampan-keeled boat of 8 m OAL with a beam of 2.7 and a draught of 0.68 m built of 1.5 cm ply wood panels are used. Propulsion is by 150 hp petrol engine (Burgess, 1966).

Thus it is clear that spiny lobsters are caught in most of the countries by diversified methods consequent to its ever increasing demand in the world markets. Location of new grounds, and adoption of newer techniques for their commercial exploitation are likely to boost the present trend of the lobster fisheries. Canada, Australia and Chile rank first in lobster catch. Others are United States, Cuba, France and South Africa. Australia is the world's largest exporter of spiny lobsters. The annual catch is between 11 to 12.5 million kg worth more than 30 million dollars per year. Today rock lobster fishing is Australia's most important fishing operation (Hughes, 1971).

In India rock lobster fishing and its trade are no more a subsistance business. After the realisation of its potential as a very lucrative export commodity, there has been a sudden spurt of activity on all fronts like fishing, processing and export, since the last 20 years. Balasubramanyan (1967) has assessed the status of the spiny lobster fishery in India and has indicated scope of further development. Despite rapid gains, lobster tails contribute only 0.82% of total quantity and 2.04% of total value of marine products exported from India in 1979 and the figures pertaining to the last five years are shown in Table 1 (Anon 1980a).

Table 1. *Landings and export of lobster tails from* 1975 *to* 1979

Year	Landings Tonnes	Export Tonnes	Value Rs.
1975	2991	402	15,76,000
1976	2532	513	3,18,02,000
1977	1217	596	3,88,04,000
1978	1307	691	4,56,68,000
1979	1136	752	5,34,65,000

With further exploration, development, conservation and judicious fishing, the export trade for spiny lobsters has a bright future. The Central Institute of Fisheries Technology, Cochin has comprehensive research plans for the development of improved lobster fishing gear and methods for exploiting lobsters of India in the coming years.

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Studies on Raschel Knotless Netting

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Production of knotless webbings is of recent origin in India. An attempt has been made to evaluate the quality of the product consequent to its introduction in the fishing industry. A method has been presented to fix up yarn specification for Raschel knotless nettings equivalent to a given knotted netting.

Knotless nets as the name implies are nets devoid of knots, the connection between meshes being made up of interlacing of the adjacent mesh bars. Loosely woven Japanese fabric used as minnow nets might have been the forerunner of knotless nets. Obviously, as a first step, its application was mainly in small meshed fine webbings, where hand braiding is laborious. Two types of knotless nets are produced namely, intertwining and Raschel type. Even though Raschel type was produced as early as 1950 in Germany (Viswanathan, 1972) its production in India is of recent origin. The present study is an attempt to evaluate the properties of the Indian knotless nets (Raschel type) produced by four different production units A1 to D1 (Table 1)

Table 1. *Mesh strength and weight of knotless netting*

Samples	Quality number	Mesh size mm	Strength of mesh (wet) kg	Weight of 100×100 meshes g	Knotted Equivalent Specification	Knotted Equivalent Weight of 100×100 meshes g
A 1	1218	10	3.84	23.7	210/1/3	32.25
A 2	1253	51	3.46	102.5	210/1/3	101.82
A 3	1211	10	2.61	26.2	210/1/2+	19.5
A 4	*1211	10	3.02	28.4	210/1/3	32.25
A 5	2416	16	4.58	74.5	210/2/2	59.7
A 6	2415	15	4.68	71.5	210/2/2	59.7
A 7	**24164	15.7	5.48	102.4	210/2/2+	62.0
A 8	2416	15	4.48	73.2	210/2/2	59.7
A 9	*2514	14	3.92	66.2	210/2/2	59.7
A 10	* 2518	18	4.0	84.6	210/2/2	64.2
A 11	*2 20	20	4.37	74.0	210/2/2	68.75
A 12	*2579	79	6.12	510.8	210/2/3	310.0
A 13	*2597	97	6.69	548.2	210/2/3	370.0
A 14	82151	14.5	12.94	1962.0	210/4/3	1106.5
B 1	2014	12	3.64	48.0	210/1/3	35.6
B 2	2425	23	6.10	90.0	210/2/3	115.5
B 3	2445	45	5.64	156.4	210/2/2+	125.4
C 1	2012	12	3.21	58.0	210/1/3	35.6
C 2	2414	14	4.53	71.2	210/2/2	59.7
C 3	2414	14	5.98	74.9	210/2/3	90.0
C 4	2416	16	4.40	76.9	210/2/2	59.7
C 5	2418	18	4.18	85.9	210/2/2	64.2
C 6	4016	16	7.8	139.0	210/2/3+	97.0
D 1	2415	15	4.44	64.0	210/2/2	59.7

* Polyethylene monofilament mixed
** Hexagonal mesh

The netting is made by special type of machines. The bars are built up by knitted stitches, very much resembling a crochet work, so made by looping of yarns referred to as looped threads (Damiani, 1964). Besides, additional woofs for strengthening are provided by another set of yarns referred to as laid-in-threads or swing threads (Fig. 1).

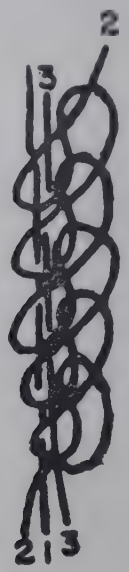

Fig. 1. Laid in threads and looped threads forming a bar in Raschel knotless netting.
1 and 3 laid in threads,
2 looped thread

A variety of difference is possible in the construction of knotless nets, depending upon (i) Choice of yarns used for looped and laid in threads:

Same denier yarn for looped and laid in threads, or finer denier yarns for looped threads and heavier denier for laid in threads or vice versa.
(ii) The method of interlacing of the threads:

Only the looped threads, or also the laid in threads, partially/wholly are entwined in the mesh apex representing the apparent knots.

According to Mugaas (1964) 'the more complex the structure of joints, the stronger and more durable they are, according to whether only the looped threads or also the laid in threads are entwined and depending upon the number of binding points (generally 2 or 4)'.

Materials and Methods

Raschel knotless webbing equivalent to 210/1/2 to 210/4/3 knotted webbings, as specified by the manufacturers, with a range of mesh sizes from 10 to 100 mm (approximately) formed the materials for the investigations. The samples were tested for the wet mesh strength, and weight for a standard dimension of webbing.

Results and Discussion

The mesh strength of the samples together with the weight of 100 x 100 meshes samples as compared to knotted equivalent is tabulated in Table 1.

The popular 210 denier nylon multifilament yarn is used as looped/laid in threads. When used as looped threads, it is paired with either the same denier or heavier denier yarn laid in threads. Samples with 210 denier yarn as laid in threads and finer yarns looped threads are also made. Use of finer denier yarns for looped threads is advantageous, since increase in weight by looping of yarns is reduced.

A knotted net is designated after its twine specification, mesh size, width and length of the webbing. Knotless nettings show quality numbers combined with dimensions of the webbing. The first digit of the quality number expresses the first digit of the denier size of looped thread yarn, the second one denotes the first digit of the denier size of laid in thread yarn and the last two digits, the size of mesh in mm.

Example		Quality No. 1225
First digit	:	First digit of the yarn denier of looped thread –150/110/180
Second digit	:	First digit of the yarn denier of laid in thread –210
Third and fourth digits	:	Mesh size in mm–25

This is the system followed by some of the Indian manufacturers.

Raschel denier of the netting which is indicative of the weight is derived by adding the denier size of laid in threads, with four times that of the looped threads, since when looped threads stitch the bars, four times the length is utilised for the formation. A

Table 2. *Comparison of theoretical and observed mesh strength of knotless netting*

Quality number	Denier		Raschel netting Mesh strength		Denier of knotted equivalent			
					Theoretical		Observed	
	Nominal	Resultant	Theoretical	Observed	Nominal	Resultant	Nominal	Resultant
12	360	810	3.25	2.61–3.84	210/1/3	756	210/1/2 to 210/1/3	504 – 756
20	420	1050	3.82	3.2–3.6	210/2/2	1008	210/1/3	756
24	630	1260	6.01	4.4–6.1	210/2/3	1512	210/2/2 to 210/2/3	1008–1512
40	840	2100	7.64	7.8	210/2/3+	1764	210/2/3+	1764

Raschel net is economical by weight if the Raschel denier is nearer, equal or is less than the resultant denier of the knotted equivalent. The sum total of the strength of laid in threads and looped threads gives the strength of Raschel netting. Laid in threads are in an almost linear position hence the strength can be equated to the linear strength of the basic yarn. Looped threads follow a complicated path, there is reduction in strength by looping equal to 25% (Tani, 1964). Based on the above assumptions, mesh strength for the different specifications of webbing was worked out and compared to observed values (Table 2).

For a knotless net with looped threads 150 denier and laid in threads 210 denier, the strength varied from 2.6 to 3.8 kg and for a netting with 210 denier and 420 denier for the two components respectively, the variation was from 4.4 to 6.1 kg. A sample with 210 denier yarns for both looped and laid in threads recorded only 3.21 kg which is even less than the values recorded by some of the samples with finer denier looped threads. Von Brandt (1964) has conducted tests with knotted and knotless nets in the range of 20 to 90 mm mesh sizes and concluded that mesh strength is independent of mesh size. It appears therefore that lower values of mesh strength observed in some samples may be due to manufacturing defects or differences in the quality of yarns.

Substitution of knotted nets with knotless nets is based on wet mesh strength (Von Brandt; 1964). It can be seen that in some cases (Samples A1, A2, B2, and C3) the theoretical values of strength (Table 2) coincide with the observed values and the weight is less than the knotted equivalents. This suggests substitution with knotless netting can be economical.

To fix up yarn sizes for exchanging knotted with knotless nets, the following calculations will be of significance.

Let X, be the denier size of nylon multifilament yarn used for looped threads having a tenacity of 6.5 g/denier. There is reduction in strength by wetting and looping of this yarn equal to 20 and 25% respectively.

Strength of looped threads will therefore be

$$= 6.5 \times \frac{75}{100} \times \frac{80}{100} \times X = 3.9\ X$$

Similarly if Y represents the denier size of laid in threads yarn, which experiences reduction in strength by wetting alone, strength will be

$$= 6.5 \times \frac{80}{100} \times Y = 5.2\ Y$$

Raschel denier of the netting $= 4\ X + Y$

To find equivalent for 210/1/3 *knitted netting*

$(3.9\ X + 5.2\ Y) \times 2 = 3360$

$4\ X + Y = 756$

3360: Mesh strength in g of 210/1/3 nylon knotted netting.

756: Resultant denier of 210/1/3 nylon twines.

Based on the above, the values of X and Y are got as 133 and 224 respectively. These are adjusted to the nearest available deniers as 150 and 210. Table 3 gives the equivalents worked out for different specifications of knotted netting twines.

Table 3. *Knotless equivalents for substituting knotted netting*

Knotted Twine size	Knotless Yarn size in denier	
	Looped thread	Laid in thread
210/1/3	150	210
210/2/2	210	210
210/2/3	210	420

Substitution with Raschel nets will be economical by weight and strength if the different combinations are made as to possess strength equal to the theoretically estimated values. This is possible, since estimations are made with minimum values of tenacity and maximum value of reduction by wetting.

Anon (1979) has reported the use of hexagonal meshes in seines as successful and economical. Data for a hexagonal webbing tested as compared to equivalent rhombic mesh is given under.

A hexagonal netting of 100 x 100 meshes of specification 24164 (16 mm mesh) weighs 102.4 g covering an area of 0.6975 sq.m.

Knotless rhombic netting of equivalent specification at 30% take up, weights 80 g with an area of 0.6362 sq.m. The same area of 0.6975 sq.m. can be covered by 88 g of the latter, rhombic mesh is less bulkier and its lesser surface coverage is more than compensated by its reduced weight.

In a knotted net, independent of mesh size, machines fabricate a definite number of knots in a given time. But in knotless, the connections as well as bars are knitted from yarns in the machines and consequently as bar size increases output in a given time decreases There is no unanimity of views regarding the mesh size above which production of knotless netting is uneconomical. But the consensus of opinion of the majority is that it is 40 mm. A second school of thought argues that as bar size increases the number of stitches per cm decreases (von Brandt, 1964). Mugaas (1964) emphasises that the coarser the yarn, the fewer are the courses per unit length. For a knotless net of 840 denier yarns (with 8–9 courses per cm), the runnage is two times that of using 210 denier yarns having 13 to 16 courses per cm, with a quantity of net equal to three times the latter.

Knotless nets are made out of yarns directly and not from finished twines. The economical production in knotless machines is achieved by the fact that the yarns for stitching are fed from sectional beams having flange diameter ranging from 355 to 535 mm (Viswanathan, 1972). This can accommodate several thousands of metres of yarn as compared to spools from which twines are fed in a knotted webbing.

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Estimation of Fish Production from Hirakud Reservoir

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A suitable procedure based broadly on stratified random sampling for estimation of fish production from Hirakud reservoir is described. The total fish production for the years 1978 and 1979 from Hirakud reservoir, along with seasonal variation of different species is discussed.

Information on the magnitude of the fishery resources is essential for the development, exploitation and conservation of any fishery. This can be achieved by assessing total fish production, species composition and variation in their abundance. Many workers have discussed estimation procedures for marine fish production (Bal & Banerjee, 1951; Sukhatme *et al.* 1958; Panse & Sastri, 1960; Banerjee, 1971; Banerjee & Chakraborty, 1972; and Krishnan Kutty *et al.* 1973). Pillai (1960), Shetty & Ghosh (1963) and Anon (1969) have described the procedures for estimating riverine and estuarine fish statistics. But so far no systematic attempt has been made to estimate the actual fish production from reservoirs. According to Padam Singh *et al.* (1978) and Sastri *et al.* (1979), the state-wise inland fish production is based on marketing figures and personal judgement. Anon (1976) stressed the need for formulating procedures to estimate the fish production from reservoirs. The foregoing is an account of such a procedure to assess the fish production from Hirakud reservoir.

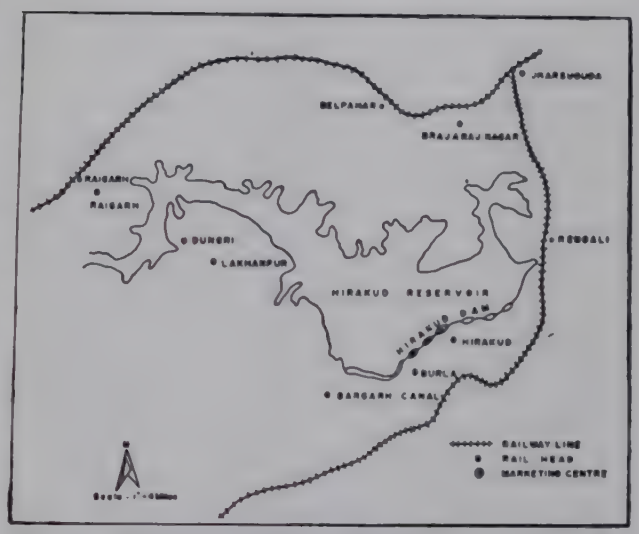

Fig. 1. Hirakud reservoir, Hirakud dam, rail heads and marketing centres

Materials and Methods

Marketing centres and rail heads were taken as the frame as the boats did not stick to definite landing centres. The weight of the fish despatched from each rail head could be obtained from the daily despatch registers of the railways. As only three rail heads were involved (Fig. 1) a complete enumeration procedure was found feasible for assessing the quantity of fish transported through rail heads. But to estimate the market arrivals the quantity brought to the market were recorded by sample survey method. For this purpose the total number of marketing centres, eight in number were listed (Fig. 1). A stratification based on the intensity of arrivals (Krishnan Kutty *et al.* 1973) was made and this resulted in the formation of two strata, one containing two good markets (Jharsuguda and Raigarh) and the other containing the rest and it was possible to record the whole quantity of fish brought to the marketing centres on selected days. By making the marketing centre days as the sampling units, a single stage sampling was found sufficient. Thus broadly, a stratified random sampling design with marketing centres as the sampling units was planned.

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Selection of the sampling units using simple random sampling, would not be appropriate as this involves space-time-variation apart from causing practical difficulties (Banerjee & Chakraborthy, 1972 and Krishnan Kutty *et al.* 1973). Following these authors, the days of observation were selected systematically with a random start and the centres randomly, in such a way that each cluster of 5 or 7 days was adequately represented. The number of marketing centres to be observed for fixing the sampling error at 10% at the monthly level was found to be approximately 14 a month, from a preliminary sample. However to fully utilise the services of two field staff, 14 days' work was programmed for each staff for sampling and for complete enumeration. In order to work out the species wise composition of the total catch recorded at the rail heads, a sampling of the fish packages brought to the rail heads was also made. For this purpose 6–7 days of observations from the rail heads in turn were made, the observation days being chosen systematically ensuring that each week was represented alike. For the good centres closer to the rail heads, the sampling days were allotted on the basis of the selection made for the rail head sampling by choosing the following day as the day of observation. The first day was chosen randomly out of the first three days of the month and the subsequent days after every fourth or fifth day. An additional day of observation was made on the preceding day of the rail head observation day in such a way that each cluster of two weeks of a month was represented alike. On this basis the sampling fraction worked out to $\frac{7\times100}{2\times30} \simeq 12\%$, for a month of 30 days. For the stratum of minor centres, the first day was selected randomly out of the first 3 days of the month as was done for the other stratum. The other days are selected systematically (every other day basis). As alternate days are included in the sample, each cluster of 5 days was equally represented. The sampling fraction for this stratum was $\frac{14\times100}{6\times30} \simeq 8\%$. Thus the good centres for which the variability in the catch was high was sampled more frequently.

The data were collected regularly both from rail heads and marketing centres as programmed. In the case of the latter, the species wise quantity of fish brought by each vendor on the day of observation was recorded. With regard to rail heads, the quantity of fish despatched on each day of the month was copied down from the concerned registers. A sample from the lot brought for despatch was examined for species-wise and total weights.

The monthly total arrivals for each stratum was estimated as: $\hat{Y} = \frac{N\times D}{n} \sum_{i=1}^{n} t_i$

where N, is the number of marketing centres in the stratum; D, the number of days in the month; n, the number of marketing-centre-days sampled and t, the total arrival at the i^{th} marketing-centre-day included in the sample. The estimated variance of this estimate on random sampling basis was obtained by

$$v\left(\hat{Y}\right) = \frac{N^2 D^2}{n} \frac{1}{n-1} \left\{ \sum_{t=i}^{n} t_i^2 - \frac{(\sum t_i)^2}{n} \right\}$$

The estimated arrivals and their variances for the entire marketing centres for a month were obtained by adding the corresponding estimates for the two strata. The estimated annual total and its variance were worked out by pooling the respective monthly totals. The standard errors of the monthly estimates (of market arrivals) were worked out as,

$$\sqrt{\sum_{1}^{2} v\left(\hat{Y}\right)}$$

and the percentage errors as,

$$\sqrt{\frac{\sum_{1}^{2} v\left(\hat{Y}\right)}{\sum_{1}^{2} \hat{Y}}} \times 100$$

The corresponding annual estimates were obtained as,

$$\sqrt{\sum_{1}^{12}\sum_{1}^{2} v\left(\hat{Y}\right)} \text{ and } \sqrt{\frac{\sum_{1}^{12}\sum_{1}^{2} v\left(\hat{Y}\right)}{\sum_{1}^{12}\sum_{1}^{2} \hat{Y}}} \times 100$$

respectively.

Table 1. *Estimated month-wise landings brought to the marketing centres and rail heads during* 1978 *and* 1979 *(in tonnes)*

	1978			1979		
	Marketing centres	Rail heads	Total	Marketing centres	Rail heads	Total
January	25.2	15.4	40.7	25.1	18.8	43.9
February	19.0	20.4	39.4	20.6	19.1	39.7
March	31.0	30.3	61.3	33.2	23.6	56.8
April	29.3	47.8	77.1	39.4	28.6	68.0
May	36.0	60.4	96.4	34.5	45.5	80.0
June	37.0	81.7	118.7	43.0	38.9	81.9
July	34.6	50.4	85.0	48.1	51.0	99.1
August	25.5	29.1	54.6	29.2	32.0	61.2
September	28.9	26.5	55.4	27.1	16.1	43.2
October	25.6	20.8	46.4	33.8	25.4	59.2
November	23.5	13.5	37.0	35.7	28.7	64.4
December	26.3	15.4	41.7	33.9	18.5	52.4
Total	342.0	411.7	753.7	403.6	346.2	749.8

Results and Discussion

Annual landings for 1978 and 1979 were estimated at 753.7 tonnes and 749.8 tonnes respectively (Table 1). But Jhingran & Tripathi (1976) have reported the annual production as 15.3 tonnes for 1965–66. This increase in output was attributable to the increased fishing effort by improved techniques in recent years. Moreover their figures were not based on regular sampling. The arrivals at local market have been estimated at 342.0 tonnes (45%) and 403.6 tonnes (54%) respectively for 1978 and 1979 (Table 1 and Fig. 3). The despatches from rail heads for the corresponding years figured 411.7 tonnes (55%) and 346.2 tonnes (46%). This discrepancy may be attributed to the disruption in the movement of boats consequent on lowering of water level in 1979 when compared to 1978. David *et al.* (1969) have observed similar phenomenon in Tungabhadra reservoir.

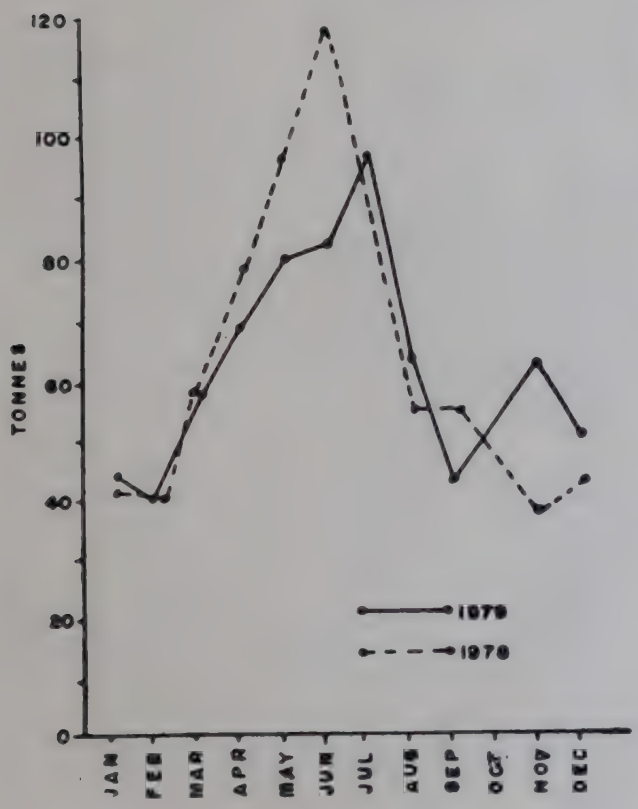

Fig. 2. Seasonal catch of fish from Hirakud reservoir

The percentage of error was the same (2.6%) in both the years and the standard errors were in the order of 8.7 and 10.4 tonnes in 1978 and 1979 respectively. With regard to monthly estimates, the standard error ranged between 1 to 4 and 1 to 6 tonnes for 1978 and 1979 respectively. The percentage error figured 4.1 to 12.2% and 5 to 13.8% for the corresponding years (Table 2). In general a tendency for higher values of error associated with higher quantity was observed. This justified an allocation proportional to the yield, as a near optimum one (Hansen *et al.* 1953) and hence the increased sampling fraction for the stratum containing the two good centres.

Table 2. *Month-wise estimated market arrivals (in tonnes), standard errors of the estimates and percentage errors in* 1978 *and* 1979

	Esimated market arrivals		Standard error		Percentage error	
	1978	1979	1978	1979	1978	1979
January	25.3	25.1	3.09	1.91	12.2	7.7
February	19.0	20.6	1.07	2.76	5.6	13.4
March	31.0	33.2	3.20	2.33	10.4	7.0
April	29.3	39.4	2.75	3.51	9.4	8.9
May	36.0	34.5	2.37	2.51	6.6	7.3
June	37.0	43.0	3.80	3.25	10.3	7.5
July	34.6	48.1	3.81	6.46	11.1	13.8
August	25.5	29.2	1.45	2.24	5.7	7.7
September	28.9	27.1	1.94	1.06	6.7	11.3
October	25.6	33.8	1.73	1.70	6.9	5.0
November	23.5	35.7	1.00	2.24	4.1	6.3
December	26.3	33.9	1.88	2.55	7.3	7.5
Total	342.0	403.6	8.74	10.39	2.6	2.6

April to July was found to be the best season for the fishery in both the years (Fig.2). This was in confirmity with earlier observations (George *et al.* 1973). The peaks occurred in June 1978 and July 1979. The peak season accounted for 47% (both years combined) of the total output. The average monthly landings during this period amounted to 88 tonnes whereas it was 50 tonnes for the remaining months. Wide fluctuations in the landings during lean months had not been observed.

The seasonal trends in the market arrivals and rail head despatches coincided with the fluctuation in the total landings (Fig. 3) in both the years. The contribution of the peak season was found to be 50% and 43.9% of the total landings in 1978 and 1979 respectively. The figures in respect of peak season for the marketing centres remained constant, while those of rail head declined from 58.4% in 1978 to 47.4% in 1979. As already stated similar trend was maintained in the annual despatches from rail heads. This variation might have been due to disruption in the transportation of fish, coupled with lesser production of quality fish during the peak season of 1979, when the major carps constituted 21% of the total catch of this period as against 29% in 1979. Since major carps formed the major constituent of fish sent to other places, the decline in landings of these fishes might have reflected in the rail head despatches.

As seen from Table 3, *M. seenghala, S. silondia* and *C. catla* accounted for 12.6, 12.5 and 12.2% of the total landings respectively in 1978, and in 1979 their figures were 16.6, 13.0 and 8.0%. In both the years, *W. attu, R. cotio, L. calbasu* and *L. fimbriatus* individually formed more than 5% of the total fish landings. The total landings of *L. rohita* declined from 6.6% in 1978 to 3.7% in 1979. This decline in the production of *L. rohita* may be due to failure of monsoon in 1979. Anon (1980) has observed similar trend in the landings of *L. rohita* and *C. catla* in Govindsagar reservoir. In the case of *W. attu* the figure for 1979 was low compared to 1978. But during 1979 the percentage of *G. chapra* rose to 7% as against 4.2% in 1978. Similar trend was also noticed in *L. calbasu*. However, most of the abundant species did not show much variation in landings.

The pattern of abundance was more or less the same in the case of predominant cat fishes like, *M. seenghala, W. attu* and *S. silondia* (Fig. 4). But the carps were not showing similar trends in the successive years. As evident from Fig. 4, the best season for

Table 3. *Species-wise landings from Hirakud reservoir during* 1978 *and* 1979 *(in tonnes)*

Name of fish	1978	1979
Catla catla (Hamilton)	91.8	62.5
Labeo fimbriatus (Bloch)	37.7	43.8
Labeo calbasu (Hamilton)	45.8	60.4
Labeo rohita (Himilton)	49.6	27.6
Labeo bata (Hamilton)	18.7	28.2
Cirrhina mrigala (Day)	21.1	12.9
Barbus tor (Day)	4.7	1.9
Barbus sarana (Day)	15.6	15.5
Mystus seenghala (Sykes)	95.3	125.1
Mystus aor (Hamilton)	7.4	6.6
Mystus tingra (Hamilton)	1.3	1.4
Silonia silondia (Hamilton)	94.2	97.8
Wallago attu (Schneider)	65.3	44.5
Eutroplichthys vacha (Hamilton)	30.6	26.2
Rita chrysea (Day)	20.2	15.1
Bagarius bagarius (Hamilton)	1.1	3.1
Notopterus chitala (Hamilton)	36.7	30.6
Notopterus notopterus (Pallas)	1.9	8.7
Gudusia chapra (Hamilton)	31.7	52.1
Rohtee cotio (Day)	56.3	55.0
Glossogobius giuris (Hamilton)	6.0	10.3
Rhinomugil corsula (Hamilton)	6.3	4.9
Sciaenids sp.	5.3	4.1
Chela bacaila	4.6	5.3
Channa sp.	3.5	3.9
Others	1.0	2.3
TOTAL	753.7	749.8

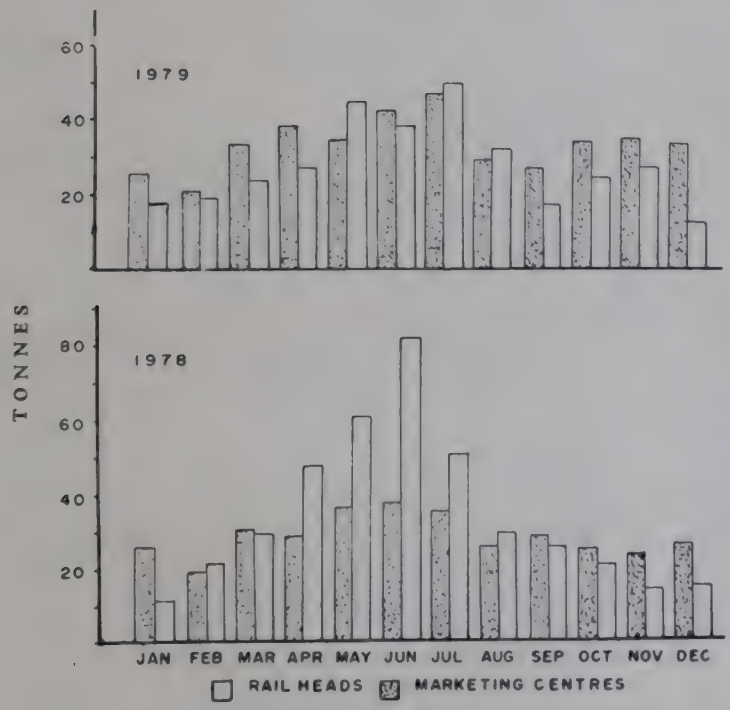

Fig. 3. Seasonal pattern in the quantities of fish arrived in the markets and despatched through rail heads in 1978 and 1979

M. seenghala, W. attu and *S. silondia* was observed to be April to August, with peaks in May (1978) and June (1979) in the case of *M. seenghala,* June 1978 and July 1979 for *S. silondia* and June (1978) and August (1979) for *W. attu.*

Of all the major carps *L. fimbriatus* showed more or less similar pattern of occurrence with a peak from May to August. In the case of *L. calbasu,* the peak was noticed in June and July respectively for 1978 and 1979. But the peak season for *C. catla* was different in these years. In 1978 maximum landing was recorded during June, September and October whereas in 1979, it was in August, October and November. However there was not much fluctuation in the landings from January to May. April to July was found to be the best season for *L. rohita* in 1978 but no specific trend could be observed in 1978, except that the catch was declining from June.

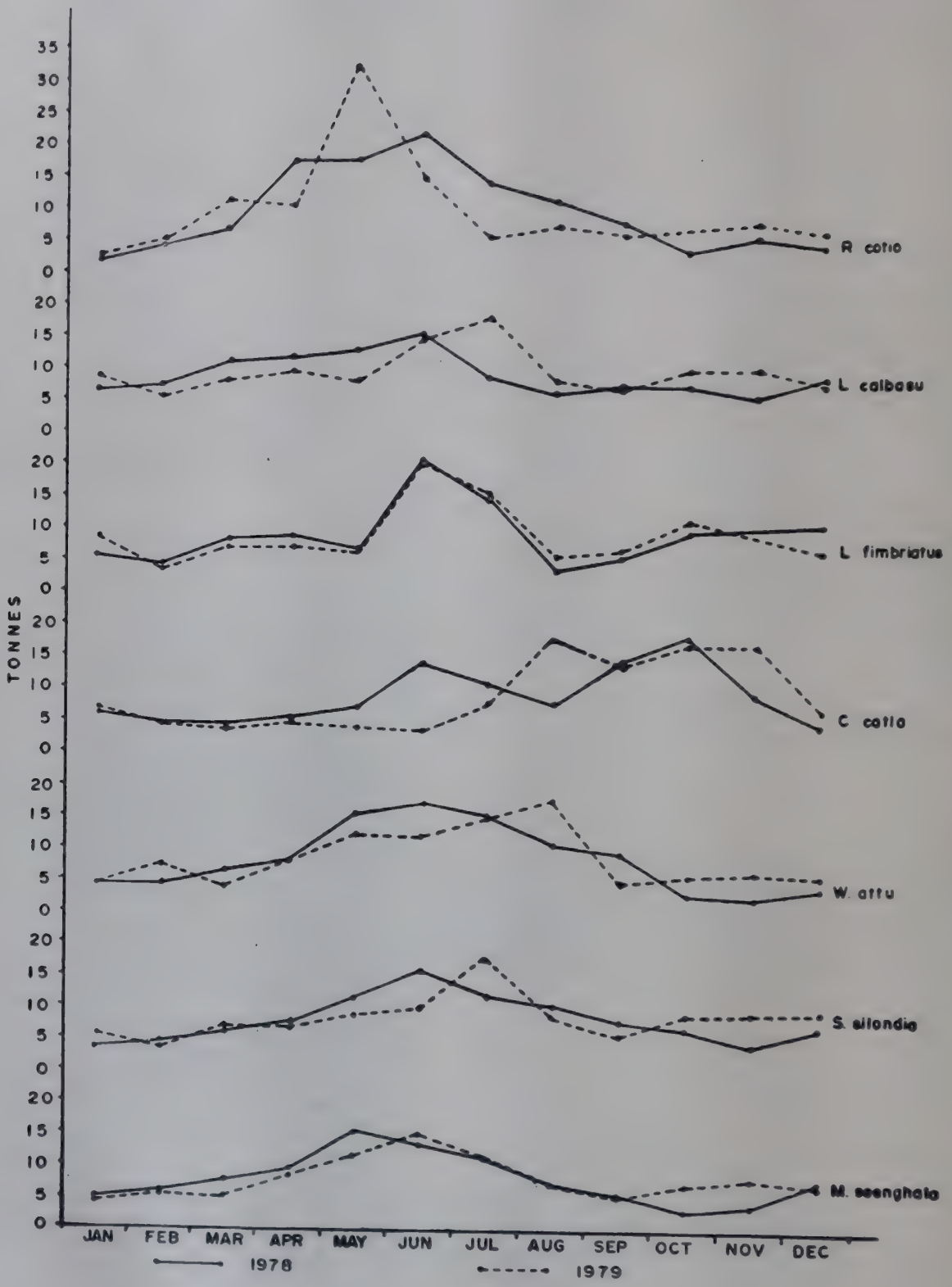

Fig. 4. Seasonal landings of important fishes from the reservoir during 1978-'79

As mentioned already the present survey covered the fish catch of the reservoir brought to the marketing centres for sale and to the rail heads for onward transportation to other places. The quantity of fish purchased direct from fishermen for human consumption could not be included owing to practical difficulties. But this does not appear to be of any significance. As some of the marketing centres are unapproachable, the possibility of omissions could not be ruled out. As is usual with other surveys the frame can be updated periodically. Inclusion of catches from ponds (sources other than reservoir) in the rail head despatches is another source of discrepancy. But this has been found to be of lesser magnitude as identified from the despatches by constant observation.

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Observations on the Lunar and Tidal Influence on Gill Netting in the Bay of Bengal

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The effect of lunar and tidal influence on the landing of pelagic fish with drift gill nets has been studied for the first time from Bay of Bengal along the Orissa coast. The catchability of the gear was highest during the first quarter and lowest in the fourth quarter of the moon. The variation in catch rates during the four different quarters was not statistically significant. Contrary to the earlier belief, landing with gill net was not poor during the moonlit nights. The extensive use of bluish grey nylon twine matching with seawater in place of indigenous hemp or cotton twine, has largely eliminated the visibility of gear during the brighter phase of the moon. The rate of exploitation was found to be significantly higher during the nights of neap tide, compared to those of spring tide. A plausible explanation for this phenomenon has been offered.

The coastal fishery is governed by several biotic and abiotic factors. The moon is one of the factors which determines the behaviour of a fish (Nomura, 1959; 1961 Hopson, 1962) and consequently its fishing. Variation in the catch owing to lunar and tidal influence is reported by Isomae (1894), Savage & Hodgson (1934), Hickling (1946), Rounsefell & Everhart (1953) and Liu (1957). From India, Jayaraman *et al.* (1959), Subramanyam (1965), Bhatt *et al.* (1967) and Kagwade (1972) have made brief observations in the variation of trawl catch in relation to the phases of moon from the Arabian sea. Although drift gill nets contribute to a major part of the pelagic fish landing of India, very little is known on the effect of moon on the gill net catch. Excepting a preliminary study by Mathai *et al.* (1971) on the landing of seer by gill nets from Cochin waters, no other information is available on this respect from the Indian subcontinent. The present paper deals with the lunar and tidal influence on the gill net catch from the Orissa coast, washed by the Bay of Bengal.

Materials and Methods

The data were collected from Chandipur, an important gill netting centre of Orissa coast. The fishing season extends from September to March and the gill nets are operated in the night from mechanised boats. The daily landing data recorded by the Orissa State Fisheries Department from 1969-'70 to 1974–'75 were analysed. As the number of boats in operation varied during the period of investigation, the catch per boat day was considered to be the catch per unit effort. The phases of the moon were followed according to the Indian calendar and the lunar month was divided into four quarters. The total quantity of fish landed during each quarter was recorded separately. The landing during the spring tides of full-moon and new-moon were compared with the neap tide catch of the first and third quarters.

Results and Discussion

The total effort in boat days and the corresponding landing during each quarter of the lunar month is appended in Table 1. The average catch was observed to vary in different quarters with a maximum in the first and minimum during the fourth quarter. To ascertain the significance if any of the lunar phase on catch, the catch per boat day for all the four quarters were subjected to chi-square (X^2) test. The calculated chi-square with 3 d.f. was 1.58, indicating that the catch rate with drift gill net in different quarters of the lunar month was not significant. The catchability during bright phase (first and second quarter) were compared with that of the dark phase (third and fourth

Table 1. *Statistics of gill net catch by the mechanised boats from Chandipur during different lunar phases*

	First quarter		Second quarter		Third quarter		Fourth quarter	
	no. of boat days	Total catch kg	no. of boat days	Total catch kg	no. of boat days	Total catch kg	no. of boat days	Total catch kg
1969–70	908	73,192	919	61,850	924	61,153	697	32,188
1970–71	844	75,693	847	68,182	971	89,229	641	59,537
1971–72	1,059	74,964	616	32,056	1,082	67,003	530	31,441
1972–73	948	56,789	566	23,375	851	35,238	527	31,152
1973–74	315	39,947	273	29,796	476	52,893	321	19,726
1974–75	568	30,065	445	28,183	322	19,859	330	13,382
Total kg	4,642	350,650	3,666	243,442	4,626	3,25,375	3,046	187,426
Average kg		75.53		66.40		70.33		61.53

Table 2. *Statistics of gill net catch from Chandipur during spring and neap tides*

	Spring tide		Neap tide	
	no. of boat days	Total catch kg	no. of boat days	Total catch kg
1969–70	209	7,900	303	22,907
1970–71	226	16,288	265	24,135
1971–72	168	5,854	245	24,043
1972–73	135	5,613	233	16,021
1973–74	48	5,407	102	14,224
1974–75	152	5,609	136	10,743
Total kg	938	46,671	1,284	112,073
Average kg		49.75		87.28

quarter). The calculated chi-square for 1 d.f. was observed as 0.15, showing no significant difference in the catch between the bright and dark phases of the moon.

The landing data with gill nets during spring tides and neap tides are presented in Table 2. The catch rate was observed to be higher during the neap tide compared to that of spring tide. The chi-square with 1 d.f. was 10.09 indicating significant difference between the two tides.

Isomae (1894) in his investigation on the catch of bluefin tuna with drift gill net, observed that the number of tuna gilled in dark nights was more than that of the moonlit nights. Savage & Hodgson (1934) noted that the herring drift net catch on the east coast of England was greatly influenced by the phases of the moon. Nomura (1959, 1961) and Hopson (1962) opined that moon is one of the several factors influencing the behaviour of fish. Hela & Laevastu (1961) laid emphasis on the visibility of net combined with the turbidity of water and current as important factors in determining fishability with drift gill nets. According to them catchability of the gill nets during nights is related to the lunar calendar, the largest catch being made usually during new-moon.

During the present investigation the catchability of the gill net was observed to vary in different quarters with highest during nights of the first quarter following new-moon

and lowest in the fourth quarter ending in new-moon. But no significant difference was observed in the catch rates of different quarters and also between the dark nights and moonlit nights. This is contrary to the common belief of a good catch during the dark phase due to poor visibility of the gear.

In India, cotton or hemp twine was formerly used for gill nets. The contrast in colour between the net and the seawater increased its visibility in the moonlit night with consequent drop in the catch and vice versa. During the past decade nylon twine has gradually replaced the indigenous netting material, the preferred colour being bluish grey that matches with the seawater. This has largely eliminated the contrast between the gear and its surrounding water, with no apparent difference in the catch during different phases of the moon.

A significant difference in the gill net catch was observed between the spring and neap tides along Orissa coast with better catches during the nights with neap tides. Mathai *et al.* (1971) noted that the dark nights with low tide to be the best period for exploitation, but did not offer any explanation. The tidal pattern near Cochin is mixed semidiurnal, whereas along the Orissa coast it is predominantly semidiurnal, with large rise of seawater during the spring tides. Near Chandipur, the difference between the spring and neap range is nearly 3 m. During the inundation of high spring tide, huge amount of detritus is washed from the beach and estuarine region into the seawater, increasing its productivity and ensuring a rich crop of plankton during the succeeding neap tide period. This would undoubtedly allure pelagic fishes resulting in better exploitation with gill nets in the nights of neap tide. In the absence of direct observation, it would be premature to predict for the rich crop of planktonic organisms during neap tide. A comparative study of hydrobiology of the coastal water in relation to the lunar phases may shed more light on this aspect.

The author is thankful to the Superintendent of Fisheries, Chandipur for allowing him to analyse the landing data.

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Comparative Study of Traditional and Improved Containers for Transportation of Fresh Fish

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Traditional bomboo basket and expanded polystyrene insulated plywood box (second hand tea-chest) were compared for transportation of iced marine, fresh water and brackish water fishes from Kakinada to Madras by rail. Quality of fish at despatching and receiving centres was assessed by organoleptic, total volatile nitrogen (TVN) and total bacterial count (TBC) tests. Based on the results obtained and the prices fetched, the traditional bamboo basket apart from being cheaper was found to be as good as expanded polystyrene insulated plywood box for short distance transportation of iced fish involving less than 24 hours journey.

Fresh fish need to be transported from landing centres to distant markets not only to fetch remunerative price but also to make fish available to the people residing far away from landing centres. It is estimated that about 70% of the total fish catch in this country is utilised as fresh and about 50,000 tonnes of fish are annually transported by rail. Containers used for transportation of fresh fish in different parts of the country vary very much depending on the type of material available locally and the traditional practice in vogue. For instance in Maharashtra and Gujarat, second hand plywood boxes (used tea-chests) are used while in Andhra Pradesh and Tamilnadu, bamboo baskets lined with leaves and mats are extensively used.

In recent years, improved containers with expanded polystyrene insulated second hand tea chests (Anon, 1965; Venkataraman *et al.* 1976) and dismantlable galvanised iron boxes with expanded polystyrene insulation (Govindan & Gupta, 1978) have been developed. Among these the former is favoured and extensively tested. But the main hurdles in its large scale use in Andhra Pradesh have been the non-availability of second hand plywood boxes of suitable capacity, high cost of plywood and insulants and the difficulty to get back the empty container and insulants for reuse. The present paper reports a comparative study of the traditional container and the improved insulated plywood box for transportation of fresh fish.

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Materials and Methods

The traditional and improved containers were used simultaneously for transporting marine (eels, lesser sardines, *Hilsa keeli*, caranx, seer), fresh water (catla, rohu and mrigal) and brackish water fishes *(Chanos chanos)* from Kakinada to Madras by rail (about 700 km in 24 h). Traditional capacity bamboo baskets of 100 to 150 kg were lined with palmyrah mat and dry leaves spread at the bottom. Ice and fish were packed in alternate layers, fish to ice ratio of 1:1.5 was used in the initial consignments but based on observations, it was replaced by 1:1 in the later consignments. Dried leaves were again spread at the top of ice, the basket closed with its lid, wrapped with gunny cloth and securely stitched. Gunny

cloth handles were provided for easy handling. The improved containers and the method of packing ice and fish were similar to those of Rao *et. al.* (1978). A few new plywood boxes of 120 kg capacity were also tried in some consignments. The fish to ice ratio of 1:1 was employed in all the improved containers.

The quality of the fish was assessed both at despatching and receiving centres by organoleptic, total volatile nitrogen (TVN), total bacterial count (TBC) and coliform counts. Total bacterial and coliform counts were determined by the standard methods employing total count agar and desoxycholate agar. Total voltatile nitrogen (TVN) was determined by Conway's micro-diffusion method (1947). The fish transported in both traditional and improved containers were marketed by the Tamilnadu Fisheries Corporation in Madras city.

Results and Discussion

All the consignments reached the destination in good condition and fetched the same price. Maximum price was fetched by seer fish (Rs. 10/kg) followed by catla, rohu and mrigal (Rs. 7/kg). The lowest priced was white baits (Rs. 1.50/kg). Eels fetched Rs. 4/kg and chanos Rs. 5/kg. The variety-wise and container-wise total bacterial counts are presented in Table 1, which reveals apparent differences in bacterial counts during transportation between containers as well as between different varieties of fish. In sardines, the change in logarithmic TBC values during transportation in basket was +1.0361 and for plywood box +0.9722. The corresponding values in eels for baskets and box were —0.4471 and —0.2407 respectively. Thus there were apparent differences in change of bacterial counts during transportation. To find out whether these differences were significant along with the factor (s) responsible for these differences, a statistical analysis was carried out (Table 2).

The differences observed in TBC values in the single variable, such as station, variety and container were not significant. Among the various first order interactions, only the interaction of variety × station could produce significant differences (at 1% level) in TBC values. None of the first order interactions involving change of container, produced significant difference in TBC values. The significant difference in TBC (at 1% level) observed in second order interaction, variety × station × container can mainly be attributed to variety × station, which was the only first order interaction producing a significant difference in TBC values. Thus based on TBC values there was no significant difference in change of the bacteriological quality of fish transported by traditional and improved containers. Chattopadhyay & Bose (1978) also observed fair bacteriological standard of fish transported in bamboo basket. The significance ($p < 0.01$) of the variety × station means that the TBC values were different

Table 1. *Total bacterial counts of fish at despatching and receiving centres*

Fish	At Kakinada	At Madras		Pooled values at Madras	Increase/ decrease %
		T*	I**		
Sardine *(Sardinella albella)*	3.5618	4.5979	4.5340	4.5660	+ 28.19
Catla	3.4968	4.3961	3.9155	4.1558	+ 18.85
Chanos	4.1308	4.0277	4.2659	4.1468	+ 0.39
Seer	3.7413	3.5567	3.8908	3.7238	— 0.46
White baits	4.4132	4.0836	4.1726	4.1281	— 6.49
Eel	4.2867	3.8396	4.0460	3.9428	— 8.02

T*— Traditional container
I**— Improved container

Table 2. *Analysis of variance for total bacterial counts*

Source	S.S.	df	M.S.	F
Between stations	0.5342	1	0.5342	<1
Between varieties	2.4951	5	0.4990	<1
Error (a)	4.3958	5	0.8791	
Between containers	0.0131	1	0.0131	<1
Variety × container	0.3275	5	0.0655	<1
Variety × station	4.3953	5	0.8791	6.99**
Station × container	0.0122	1	0.0122	<1
Variety × station × container	5.0625	5	1.0125	8.06**
Error	6.0288	48	0.1256	
Total	18.8686	71		

** Significant at 1% level

Table 3. *Total volatile nitrogen values of fish at despatching and receiving centres–mean values (log)*

	At Kakinada	At Madras		Pooled mean at Madras	Increase/ decrease %
		T*	I**		
White baits	0.7347	1.1847	1.4179	1.3013	+77.2
Sardine *(Sardinella albella)*	0.7195	1.0931	1.2773	1.1852	+64.7
Chanos	0.5396	0.7702	0.7747	0.7724	+43.2
Seer	0.8198	1.0055	0.9705	0.9880	+20.5
Catla	0.9695	1.2059	1.1580	1.1819	+19.4
Eels	0.8938	0.8993	0.7902	0.8448	— 5.5

T* — Traditional container
I** — Improved container

Table 4. *Particulars of meltage of ice during transportation*

Container	Number of observations	Fish : ice ratio	Ice left over (%) Mean ± S.D.
Improved	18	1:1	46.4 ± 14.9
Traditional	5	1:1	23.6 ± 4.1
Traditional	17	1:1.5	24.5 ± 9.9

among varieties between the two stations. Thus significant differences in quality during transportation were noticed in different fishes in this study indicating that certain fishes are more suitable for transportation. None of the consignments revealed coliforms at despatching and receiving centres. The TVN values are given in Table 3. There was no significant difference in TVN values of fish transported in the two types of containers, but significant differences were noticed in TVN values among different varieties of fishes during transportation indicating that both the types of containers were equally good.

The details of fish to ice ratio at the transporting centre (container-wise) and the ice left over at the destination (in percentages) are presented in Table 4. The percentage

Table 5. *Cost details of traditional and improved containers*

Traditional	Rs.	Ps.	Improved	Rs.	Ps.	Improved	Rs.	Ps.
Bamboo basket, 150 kg capacity	5	00	Plywood box, 120 kg capacity	48	00	Second hand tea chest, 45 kg capacity	3	50
Palmirah mat	3	20	Expanded polystyrene (25 mm, 58.5 x 48.2 x 48.2 cm)	46	00	*Expanded polystyrene calculated for one trip	9	75
Badam leaves	0	50	Polythene sheet	6	00	Polythene sheet	3	45
Gunny, sutli (country twine) etc.	5	00	Gunny, coir rope, sutli (country twine), nails etc.	5	00	Gunny, rope, sutli, nails etc.	3	25
Total	13	70				Total	19	95
Say Rs. 14, for transporting 60 kgs of fish			Cost of gunny, polythene, rope sutli, nails etc. for 2 additional trips	22	00	Cost for transporting 22 kg fish in second hand teachest insulated container	19	95
Cost per kg fish	00	24	Return freight for the empty containers and insulation for three trips	9	00	Cost per kg fish	00	90
			Disinfectant	1	00			
			Total	137	00			
			This new container along with insulation can be used for three trips.					
			Cost for 3 trips	137	00			
			Cost for 1 trip	45	60			
			Cost for transporting 60 kg fish in improved container	45	60			
			Cost per kg of fish	00	76			
			*Expanded polystyrene insulation can be used for 3 trips					

left over of ice was more at the destination in improved containers, when compared to the baskets indicating better insulation in improved container. Sufficient quantities of left over ice was noticed in baskets which was found sufficient for unexpected delays in transit. 1:1 fish to ice ratio was found to be adequate even in the traditional container for transhipment from Kakinada to Madras in 24 h.

The packing cost of the traditional and improved containers are presented in Table 5. The packing charges per kg of fish for traditional container was 0.24 rupees per kg while that of used tea chests and newly fabricated plywood boxes were 0.90 and 0.76 rupees respectively. The traditional bamboo basket performed equally well as those of insulated boxes during transhipment of fish from Kakinada to Madras by rail involving 24 hours journey. It may be worth while to study the comparative efficiency of these containers for long distance rail transportation such as from Madras to Howrah.

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Effect of Frozen Storage on the Physical Properties of Corrugated Fibre-Board Master Cartons and Waxed Duplex Cartons

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Deteriorative changes in physical properties of corrugated fibre-board master cartons and waxed duplex cartons during frozen storage under commercial conditions were studied. Such changes due to prolonged exposure of these boards to moisture in the laboratory, effect of repeated wax-coating on the water resisting capacity of the boards and protection provided by increasing wax contents in the boards against water absorption and consequent deterioration in physical properties are reported.

No information is available on the probable deteriorative changes in fibre-board master cartons and waxed deplex cartons employed in frozen storage under commercial conditions. Alterations taking place in physical properties of corrugated fibre-board master cartons and waxed duplex cartons in frozen storage upto 6 months, simulating conditions obtaining in the industry are reported in this communication. Effects of prolonged exposure of these boards to moisture on their physical properties and increasing wax contents in the boards on their water resisting capacities and consequent retension of physical properties have also been studied.

Materials and Methods

Commercial samples of corrugated fibre-board master cartons (unwaxed, 5-ply, B flute, 651 gsm) and waxed duplex cartons used in frozen shrimp export trade were procured from local manufacturers. They were subjected to complete analysis of the properties before commencing the experiment, employing methods reported in the earlier communications (Srinivasa Gopal & Govindan, 1980). Two kg lots of finely crushed ice were packed in the duplex cartons with 100 gauge low density polythene film linings inside. Ten such cartons were arranged in one master carton and wound with 12 mm wide polypropylene straps with the help of a strapping machine. The entire operation was carried out exactly as practised in commercial shrimp freezing factories, excepting for the fact that ice replaced the frozen shrimp. Six such master cartons were got ready and held in frozen storage at–18 to –20°C (R.H. 80–85%). At the end of each month one master carton was withdrawn from the storage, opened, ice emptied and both the master and duplex cartons subjected to complete analysis. Moisture content, bursting strength and puncture resistance were determined in the case of master cartons. In duplex cartons, moisture, bursting strength, puncture resistance, tensile strength and elongation (in the lengthwise direction of the carton) and tearing strength in both machine and cross directions were studied. The studies were continued upto 6 months of frozen storage.

Since absorption of moisture by the carton material is the main cause of deterioration in its properties, samples of both the corrugated and duplex boards (unwaxed) were exposed to moisture on one side for 1, 2 and 3 hours and changes occurring in their physical properties studied. As the quantity of wax impregnated into the material is one of the major decisive factors in its water resisting capacity, corrugated fibre-boards and duplex boards used in frozen shrimp cartons were procured and impregnated with different quantities of wax. This was done by passing pieces of the boards through molten wax once, twice and thrice successively using a wax-coating machine generally employed by commercial carton manufacturers. Changes in properties due to waxing were studied. The

Table 1. *Effect of frozen storage on properties of master cartons (Grammage of the board:651 gsm)*

Period of storage months	Moisture %	Bursting strength kg/sq.cm	Puncture resistance beach units
Nil	6.67	13.5	185
1	14.12	13.5	175
2	14.50	11.5	170
3	14.09	11.5	185
4	15.19	10.0	170
5	14.52	10.2	159
6	19.10	8.2	150

Table 2. *Effect of frozen storage on physical properties of waxed duplex cartons (Grammage of board: 345 gsm, Wax content: 8.5%, Saponifiable matter: 2.94%)*

Period of storage months	Moisture %	Bursting strength kg/sq. cm	Puncture resistance beach units	Tearing strength Cross direction g	Tearing strength Machine direction g	Tensile strength kgf	Elongation cm/18 cm
Nil	5.45	3.75	21	180	168	16.26	0.6
1	9.19	3.75	20	152	128	10.97	–do–
2	9.54	3.50	20	160	128	11.08	–do–
3	9.60	3.50	20	128	112	9.05	–do–
4	9.60	3.25	20	144	120	10.95	–do–
5	9.70	3.25	19.5	144	120	10.75	–do–
6	9.79	3.25	19	144	120	10.70	–do–

waxed samples of the boards were exposed to moisture for 1, 2 and 3 hours by clamping them in modified specially designed Cobb's apparatus and keeping a height of 4 cm of water above the samples each time. After the exposure periods, the adhering water was removed by a filter paper and changes occurring in all the physical parameters followed.

Results and Discussion

Deteriorative changes taking place in master cartons during frozen storage for 6 months are presented in Table 1. A sudden spurt was observed in the moisture content even after one month of storage. This may be partly attributed to the fact that the cartons were not wax-coated. Thereafter the increase was not so marked till the end of the fifth month. After 6 months a further steep increase was noted. Corresponding decreases occurred in bursting strength and puncture resistance, significant changes in them being registered only after 2 to 3 months of storage. Alterations in these parameters are caused by condensation of moisture on the cartons due to fluctuations of temperature occurring during opening of the frozen storage. Even though moisture uptake is comparatively quicker, the havoc done by it on the physical properties is slower. Moisture in the board is a very important factor affecting physical strength, flexibility, sheet forming characteristics, as also its weight, dimentional stability, rigidity, folding endurance, elasticity and above all its thermal properties. Fall in bursting strength is attributable to loss in strength and toughness of the fibres by the action of moisture. The decrease in puncture resistance is the root cause of frequent puncture of the master cartons held in frozen storage by corners of other cartons, lumbers and forks when they are subsequently handled for transportation.

Table 2 gives the changes in physical properties of waxed duplex cartons during frozen storage for 6 months. The increase in moisture is maximum after the first month in frozen storage. However, the percentage increase is less than that in the former,

which may be attributed to the protection offered by the former and the wax coating against moisture penetration and the comparatively lower grammage of the latter (345 gsm.). The fall in bursting strength is only 13.3% after six months compared to 39% in master carton. Puncture resistance decreased by 9.5% during storage. Tearing and tensile strengths were the most affected. The former showed a fall of 20% in cross direction and 28.6% in machine direction in 6 months. Most drastic change was observed in tensile strength, a fall of 34.2% of the original.

Changes in moisture, bursting and tearing strengths and puncture resistance occurring in plain corrugated fibre-boards and duplex boards, when exposed to moisture on one side for varying periods are presented in Table 3.

Prolonged exposure to moisture and its consequent absorption drastically affects all the important physical properties. In commercial practice, duplex cartons are exposed to glazing water both in the case of in-carton freezing and in tray-freezing at the stage of packing. The absorption continues for varying lengths of time until all the free water freezes into ice. Master cartons are usually exposed inadvertently to occasional splashes of glaze water and to wetness of the surface on which they are placed. Condensation of water also occurs on the surface of the master cartons due to fluctuations in temperature of the frozen storage, dripping of water drops from the roof of the storage and during transhipment. Under all these circumstances, water is absorbed into the carton material, causing deterioration in their physical properties.

Table 3. *Changes in physical properties of plain corrugated fibre-board and duplex board during prolonged exposure to moisture*

Physical properties	Corrugated fibre-board				Duplex board			
	A	B	C	D	A	B	C	D
Moisture	6.67	19.35	21.46	22.76	7.55	22.92	25.59	28.21
Bursting strength kg/cm²	11.5	7.5	6.75	6.25	3.40	1.05	0.90	0.65
Puncture resistance beach units	210.0	127.5	117.5	115.0	20.5	10.5	8.5	6.75
Tearing strength g								
Cross direction	...	...	...	...	176.0	64.0	48.0	40.0
Machine direction	...	...	...	...	165.5	56.0	40.0	32.0

A Control (before exposure to water)
B After 1 h exposure to water
C After 2 h exposure to water
D After 3 h exposure to water

Table 4. *Changes in physical properties of corrugated fibre-board and duplex board after repeated wax-coating*

Stage of analysis	Corrugated fibre-board		Duplex board	
	Cobb 30′ value	Wax content %	Cobb 30′ value	Wax content %
Initial (before wax-coating)	108.45	Nil	66.16	Nil
After wax-coating once	87.05	6.68	39.80	11.90
After wax-coating twice	25.06	9.01	32.54	13.77
After coating thrice	19.49	9.84	30.00	16.29

The changes in physical properties of corrugated fibre-board and duplex board brought about by wax-coating once, twice and thrice are presented in Table 4. Wax coating causes significant improvement in the moisture resistance as shown by the decreasing Cobb 30′ values. Wax contents in the boards increase with the number of times they are waxed with simultaneous decrease in Cobb 30′ values. Two wax coating treatments appear to be sufficient to impart desirable degree of water resisting property to the board. The other characteristics of the boards, namely moisture, bursting strength, puncture resistance and tearing strength are not however affected in any way by wax coating.

Table 5 depicts the changes in moisture, bursting strength and puncture resistance of the wax-coated corrugated fibre-boards after exposure to water for 1,2 and 3 hours at one side to a depth of 4 cm. The uptake of water is maximum in the control sample (Table 3), moisture increasing more than three times in three hours, greatest increase occurring in the first hour of exposure. Moisture uptake in the first hour in both twice and thrice coated samples is comparable, while during subsequent continued exposure, the latter exhibits greater resistance (Table 5). This is a very important phenomenon to be reckoned with since moisture condensation on the master cartons takes place to some extent due to fluctuations of temperature and humidity in the frozen storage during opening and closing of the doors and to considerably high degrees while transporting the frozen cargo in insulated vans. The condensed moisture gets absorbed into the carton material weakening its physical properties. This is amply borne out by the drastic falls in bursting strength and puncture resistance values along with increases in moisture contents. It may incidentally be pointed out that wax-coating does not alter these characteristics as they are the inherent properties of the material constituting the board and hence initial values of the control board hold good for the wax-coated samples also prior to exposure to moisture.

Table 5. *Changes in physical properties of corrugated fibre-board (wax coated) due to exposure to water*

Sample	Moisture %	Bursting strength kg/sq.cm	Puncture resistance beach units
Initial values	6.67	11.50	210
Wax-coated once			
A	16.28	7.50	150.0
B	18.24	6.50	130.1
C	19.65	6.50	120.0
Wax-coated twice			
A	7.78	10.0	190.0
B	16.18	8.5	150.0
C	16.58	7.5	137.5
Wax-coated thrice			
A	8.09	9.0	197.5
B	10.22	9.0	185.0
C	12.29	9.0	175.0

A After 1 h exposure to water
B After 2 h exposure to water
C After 3 h exposure to water

Table 6. *Changes in properties of waxed duplex board due to exposure to water*

Sample	Moisture %	Bursting strength kg/sq.cm	Puncture resistance Beach units	Tearing strength g	
				Cross direction	Machine direction
Initial values	7.55	3.40	20.50	176	165.5
Wax-coated once					
A	16.28	1.75	17.75	120	114
B	19.93	1.40	13.75	104	96
C	22.28	1.25	12.25	100	88
Wax-coated twice					
A	13.90	1.70	18.00	136	120
B	20.00	1.40	17.50	126	113
C	20.92	1.50	13.25	116	96
Wax-coated thrice					
A	13.74	2.40	19.50	144	124
B	18.53	1.40	16.25	128	112
C	20.46	1.50	15.50	120	112

A After 1 h exposure to water
B After 2 h exposure to water
C After 3 h exposure to water

Changes occurring in moisture, bursting strength, puncture resistance and tearing strength in both cross and machine directions in duplex boards coated with different percentages of wax on exposure to water to a depth of 4 cm from one side for 1, 2 and 3 hours are presented in Table 6. The pattern of changes is similar to that in corrugated board. Moisture in the control sample multiplies nearly 4 times after exposure to water for 3 hours (Table 3). Even though the percentages of wax imbibed are comparatively more in duplex boards (Table 4), their water intake is more than that of the corrugated boards with smaller percentages of absorbed wax. Hence the amount of wax alone is not the decisive factor in the matter of fluid absorption. It is known that amount of sizing, sheet density and ash content are some other factors over and above wax content which contribute towards building up resistance against fluid penetration in papers (Anon, 1973). Rates of deterioration in physical properties namely, bursting strength, tearing strength and puncture resistance are comparatively more pronounced in the duplex board along with absorption of water (Table 6).

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Studies on the Chemical Control of Psychrophilic Bacterial Spoilage of Fish. ii - The Effect of Antibiotics on the Growth of Psychrophilic Bacteria Isolated from Marine Fish

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Among the various antibiotics tried, tetracyclines particularly chlorotetracycline (CTC), chloramphenicol and chlorostrep were found to be fairly effective at 8 and 10 p.p.m. levels. The order of sensitivity to CTC among the six genera studied was found to be *Achromobacter* < *Flavobacterium* < *Pseudomonas* < *Micrococcus* < *Vibrio* < *Alcaligenes*. It was observed that species belonging to *Achromobacter, Flavobacterium* and *Pseudomonas* were generally more resistant to antibiotics than species belonging to other genera. Among the resistant organisms, *Achromobacter superficialis* was found to be most resistant and only CTC at 10 p.p.m. level could partially inhibit this culture. The useful combinations of antibiotics for commercial application are discussed.

A large number of antibiotics have been tried earlier as preservatives to check the growth of psychrophilic flora of fish stored in ice to extend its shelflife for a reasonably long period (Tarr *et al.*, 1952; Tomiyama *et al.*, 1955; Velankar & Sastri, 1958; Suilt *et al.*, 1970; Surendran & Iyer, 1973). While most of these earlier studies have confined to direct testing of the preservatives on fish, only a few attempts have been made to understand the effect of these preservatives on psychrophilic cultures commonly encountered on marine fishes (Heather & Vanderzant, 1958; Velankar, 1958; Surendran & Iyer, 1971, 1976; Tunstall & Gowland, 1974). Even here no comprehensive studies have been done, so far. While working towards the above objective the authors have already reported on the isolation of psychrophilic cultures from marine fishes of South Kanara Coast of Karnataka (Anand & Setty, 1977). In this paper, the effect of various antibiotics on those psychrophilic cultures is presented.

Materials and Methods

The antibiotics tried were Aureomycin (Cyanamid India), Terramycin (Pfizer), Tetracycline (Indian Drugs and Pharmaceuticals), Chloramphenicol and Chlorostrep (Parke Davis), Dihydrostreptomycin (Sigma) and Bacitracin (NBC).

Six genera of psychrophilic bacterial cultures isolated from marine fish (Anand & Setty, 1977) and employed in this study are given in Table 1.

The medium used for testing the sensitivity of cultures consisted of glucose 0.1%; bacto-peptone 0.5%; beef extract 0.3%; sodium chloride 3.0%; agar 1.5% prepared in distilled water. The pH was adjusted to 7.2 and sterilized for 20 min at 1.05 kg/cm² pressure. The chemicals used for the medium were either Difco or BDH make.

The plate culture technique employed consisted of incorporating known concentration of preservative into the sterilized and cooled medium before pouring on to the plates. The plates were divided into four parts by marking on the plates with a glass mark and each part was inoculated with a different culture, thus covering four cultures per plate per concentration of the preservative. The inoculum consisted of freshly grown cells prepared from a 24 h old slant culture whose optical density was adjusted to 0.5 always and a loopful of these was placed at the centre of each part as a spot and slightly spread out. The plates were incubated at 25–28°C for 96 h and presence or absence of growth was recorded every 24 h. Depending on the extent of growth, grades were given as shown in the

Table 1. *Cultures selected for the study*

Culture number	Identity
1	*Achromobacter aquamarinus*
2	*Achromobacter delicatulus*
3	*Achromobacter liquefaciens*
4	*Achromobacter superficialis*
5	*Alcaligenes bucheri*
6	*Alcaligenes faecalis*
7	*Flavobacterium diffusum*
8	*Flavobacterium halmephilum*
9	*Pseudomonas fragi*
10	*Pseudomonas sp.*
11	*Micrococcus conglomeratus*
12	*Micrococcus varians*
13	*Vibrio costicolus*

tables. This type of grading was done as the work was qualitative rather than quantitative. Suitable control for each preservative was included.

Results and Discussion

The results of the seven antibiotics are shown in Tables 2 and 3. Four concentrations namely 4, 6, 8 and 10 p.p.m. have been tried on the 13 selected cultures drawn from different genera of psychrophiles mentioned in Table 1.

As seen from Table 2, chloroteracycline (CTC) was found to be effective at 8 p.p.m. concentration for all the cultures except two species each of *Archromobacter* (culture nos. 3 and 4) and *Flavobacterium* (7 and 8) genera. CTC at 10 p.p.m. level could further inhibit the growth of cultures 3 and 7 and partially 4 and 8. Oxytetracycline (OTC) at 8 p.p.m. was found to be equally effective like CTC but could not inhibit two species of *Achromobacter* (3 and 4) and one species each of *Flavobacterium* (8), *Pseudomonas* (9) and Vibrio (13). However, OTC at 10 p.p.m. could inhibit *Vibrio* sp. Surprisingly enough, tetracycline (TC) was found to be even more effective than CTC and OTC against these cultures. However, 8 and 10 p.p.m. levels of TC were effective against most of the cultures but not against cultures 4, 8 and 10. It may be seen that one species each of *Achromobacter, Flavobacterium* and *Pseudomonas* are not inhibited again by TC like the other two tetracycline derivatives.

As shown in Table 3, dihydrostreptomycin had very little effect in checking the growth of these cultures except that it could inhibit only one species each of *Achromobacter* (2), Alcaligenes (6) and Pseudomonas (10). Streptomycin in combination with chloramphenicol (Chlorostrep) could inhibit almost all cultures at 8 and 10 p. p. m. levels except culture 4. However chloramphenicol alone at 10 p.p.m. level was found to be even more effective than chlorostrep since it could inhibit all cultures, including culture 4 to some extent. Here again *Achromobacter superficialis* (4) stood out as the most resistant organism among these cultures.

Bacitracin, however was not found to be effective against these cultures at any of the concentrations tried in the study.

The effect of various antibiotics on different species belonging to six genera was, however, highly varying. It was generally seen that species belonging to *Achromobacter, Flavobacterium* and *Pseudomonas* were more resistant than species belonging to other groups. Among the resistant organisms, *Achromobacter superficialis* was found to be most resistant to antibiotics. Earlier studies by Kawabata *et al.* (1962) showed that CTC resistant bacteria isolated from CTC treated fish belonged to the above three genera and they were mainly responsible for putrefaction of fish stored under ice.

Among the resistant organisms, *Achromobacter superficialis* (culture no. 4) was found to be more resistant to tetracyclines than others and only CTC at 10 p.p.m. level could partially inhibit this culture. While *Achromobacter liquifaciens* (culture no. 3) was resistant to CTC even at 10 p.p.m. level, it was, however, easily susceptible to OTC and TC. The susceptibility of *Pseudomonas* sp. though varied with respect to OTC and TC, they were inhibited by CTC. *Alcaligenes, Micrococcus* and *Vibrio* were, however, susceptible to all the three tetracyclines.

Comparing the effect of other antibiotics, chloramphenicol was found to be more potent than others in checking the growth

Table 2. *Effect of tetracyclines on the growth of selected cultures*

Preservatives	Chlorotetracycline								Oxytetracycline								Tetracycline							
Concn. of preservative p.p.m.	4		6		8		10		4		6		8		10		4		6		8		10	
Incubation h	48	96	48	96	48	96	48	96	48	96	48	96	48	96	48	96	48	96	48	96	48	96	48	96
Culture number																								
1	—	—	—	—	—	—	—	—	±	±	—	—	—	—	—	—	±	—	—	—	—	—	—	—
2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
3	∓	+	—	+	—	+	—	+	—	±	—	±	—	∓	—	—	—	+	—	±	—	+	—	—
4	±	+	±	+	±	±	±	±	±	+	±	—	±	+	±	—	+	+	+	+	+	+	+	+
5	—	—	—	—	—	—	—	—	±	±	—	—	—	—	—	—	±	±	—	—	—	—	—	—
6	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
7	∓	+	—	±	—	∓	—	—	—	—	—	—	—	—	—	—	—	+	—	∓	—	—	—	—
8	—	+	—	±	—	±	—	±	∓	+	∓	±	—	∓	—	∓	∓	±	∓	±	—	±	—	∓
9	—	±	—	—	—	—	—	—	—	+	—	+	—	∓	—	∓	—	±	—	—	—	—	—	—
10	∓	+	—	+	—	—	—	—	—	—	—	—	—	—	—	—	—	+	—	±	—	±	—	∓
11	—	+	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
12	—	±	—	—	—	—	—	—	—	+	—	+	—	—	—	—	—	±	—	—	—	—	—	—
13	—	±	—	—	—	—	—	—	—	±	—	∓	—	∓	—	—	—	—	—	—	—	—	—	—

All cultures showed good growth in 24 h in control plates. Initial pH 7

Key: + good growth; — no growth; ± slight growth; ∓ very slight growth

Table 3. *Effect of other antibiotics on the growth of selected cultures*

Preservatives	Dihydrostreptomycin								Chlorostrep								Chloramphenicol							
Concn. of preservative p.p.m.	4		6		8		10		4		6		8		10		4		6		8		10	
Incubation h	48	96	48	96	48	96	48	96	48	96	48	96	48	96	48	96	48	96	48	96	48	96	48	96
Culture number																								
1	+	+	+	+	+	+	+	+	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
2	—	—	—	—	—	—	—	—	—	∓	—	—	—	—	—	—	—	—	—	—	—	—	—	—
3	—	+	—	∓	—	∓	—	∓	+	+	—	+	—	±	—	—	±	+	—	±	—	±	—	—
4	±	±	±	±	±	±	±	±	+	+	+	+	+	+	+	+	+	+	+	±	+	±	+	—
5	+	+	+	+	+	+	+	+	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
6	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
7	—	±	—	∓	—	∓	—	—	—	∓	—	—	—	—	—	—	±	∓	—	—	—	—	—	—
8	+	+	+	+	+	+	+	+	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
9	∓	+	±	+	±	+	±	±	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
10	—	±	—	±	—	—	—	—	—	±	—	∓	—	—	—	—	+	+	—	±	—	—	—	—
11	—	+	—	±	∓	±	±	±	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
12	+	+	±	+	±	+	±	+	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
13	+	+	+	+	+	+	+	+	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—

All the cultures showed good growth in control plates. Initial pH 7

Key: + good growth; — no growth; ± slight growth; ∓ very slight growth

of all cultures except *Achromobacter superficialis* which could show slight growth even at 10p.p.m. concentration. Higher levels of these antibiotics may be effective against this culture. The use of chloramphenicol as a preservative for fish appears to be rather doubtful as it has not been allowed for use by any country so far. From this point of view, a combination of CTC and OTC or CTC and TC appears to be more practicable. With regard to the sensitivity of various groups of organisms to CTC, Surendran & Iyer (1971) found that the order of sensitivity was *Pseudomonas* < *Vibrio* < *Achromobacter* < *Flavobacter* at 5 and 20 p.p.m. levels. However the present study indicates that the order to be < *Achromobacter* < *Flavobacter* < *Pseudomonas* < *Micrococcus Vibrio* < *Alcaligenes*. The *Pseudomonas* group which forms one of the major groups among psychrophiles commonly found in fish and which is responsible for rapid spoilage during cooler storage, has been found to be quite sensitive to many of the antibiotics like CTC, OTC and TC (Heather & Vanderzant, 1958; Velankar, 1958), Streptomycin, Kanamycin, colistin, neomycin, polymyxin and thiosporin (Tunstall & Gowland, 1974). However, some species of *Pseudomonas* like *P. fluorescens* have been found to be quite resistant to antibiotics (Kawabata *et al.* 1962)

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Studies on the Chemical Control of Psychrophilic Bacterial Spoilage of Fish. iii - The Effect of Chemical Preservatives on the Growth of Psychrophilic Bacteria Isolated from Marine Fish

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Among the six chemical preservatives tried, propyl and methyl paraben were found to be very effective in inhibiting the growth of all the cultures. While propyl paraben could check the growth of all the cultures at 0.1% level, methyl paraben could do the same only at 0.2% level. The other preservatives namely, orthochlorobenzoic acid (upto 0.2%), sodium hypochlorite (upto 25 p.p.m.) ethoidin (upto 0.025%) and polyethylene glycol (upto 4 p.p.m.) had no inhibitory effect on any of the cultures tried.

Earlier attempts to use chemical preservatives to extend the storage life of ice-stored fish have not yielded any useful results. (Tarr & Deas, 1948; Tetsumoto & Yamada, 1948; Shewan, 1956). Recently a few attempts have been made to test the effectiveness of some of these preservatives on the spoilage organisms isolated from fish rather than testing them directly on fish (Heather & Vander Zant, 1958; Surendran & Iyer, 1971; Anand & Setty, 1977). In this paper the results of our studies with six of the various chemical preservatives tried on the representative cultures belonging to six genera are presented.

Materials and Methods

The chemical preservatives used were propyl-hydroxy-4-benzoate (E. Merck), methyl-para hydroxy benzoate (Societe. des Usiness Chemicques, France), o-chlorobenzoic acid (Veb Laborchemic Apolda, Germany), sodium hypochlorite (Chempure Ltd., India), polyethylene glycol 400 (Glaxo, India) and 6, 9-diamino-2-ethoxy acridine lactate (Sigma).

Cultures used in the study (Table 1) were selected from a large number of psychrophilic bacterial cultures isolated from marine fish belonging to six genera (Anand & Setty, 1977)

Table 1. *Cultures selected for the study*

Culture number	Identity
1	*Achromobacter aquamarinus*
2	*Achromobacter delicatulus*
3	*Achromobacter liquefaciens*
4	*Achromobacter superficialis*
5	*Alcaligenes bucheri*
6	*Alcaligenes faecalis*
7	*Flavobacterium diffusum*
8	*Flavovacterium halmephilum*
9	*Pseudomonas fragi*
10	*Pseudomonas* sp.
11	*Micrococcus conglomeratus*
12	*Micrococcus varians*
13	*Vibrio costicolus*

The medium used for testing the sensitivity of cultures consisted of glucose 0.1%, bactopeptone 0.5%, beef extract 0.3%, sodium chloride 3.0%, agar 1.5% prepared in distilled water. The pH of the medium was adjusted to 7.2 and sterilized for 20 min at 1.05 kg/cm² pressure. The chemicals used for the medium were either Difco or BDH make.

Plate culture technique is the same as described by Anand & Setty (1981).

Nutrient broth medium was distributed into 30 ml test tubes in 15 ml quantities and

sterilized at 1.05 kg/cm² pressure for 20 min. These tubes were inoculated with different test organisms and after growing them for 24 h the various preservatives at different concentrations were introduced. The optical density of the inoculum was always adjusted to 0.2. The tubes were incubated at 25–28°C for 72 h and the growth was recorded turbidimetrically every 12 h. Suitable controls were always included in all cases. Wherever the preservatives were not easily soluble in water, small amount of alkali was used to dissolve them and the pH of the medium was suitably adjusted after the addition of the preservatives.

Growth measurements were done turbidimetrically in a Klett-Summerson colorimeter using the green filter (no. 54). pH recorded with BDH pH indicator papers. As there was no difference in the effectiveness of preservatives on these cultures at 0–5°C and at 25–28°C, the plate and broth culture experiments were carried out at 25–28°C to obtain quick results.

Results and Discussion

Four concentrations of each chemical preservative were selected (Tables 2–5) for plate culture studies depending on the nature of the chemical and the concentrations used by earlier workers.

Among the two parabens tried (Table 2), propyl paraben was found to be very effective for all the cultures at 0.1% and above.. Methyl paraben was however not effective to many of these cultures upto 0.15% level and only at 0.2% was effective against all the cultures. The fact that all the four species of *Achromobacter,* particularly culture no. 4 *(Achromobacter superficialis),* which was not inhibited by most of the antibiotics tried (Anand & Setty, 1981) are inhibited by propyl paraben, even at 0.1% level is noteworthy for future considerations. Though methyl paraben is effective at higher concentration, its use as a commercial preservative for fish at such high concentrations is rather doubtful.

The two chloro compounds namely, o-chlorobenzoic acid and sodium hypochlorite were found to be not effective to all the cultures at the concentrations used in the study (Table 2). It may be seen from the tables that sodium hypochlorite had some amount of inhibitory effect on majority of the cultures even at 15 and 20 p.p.m. levels (as available chlorine), whereas o-chlorobenzoic acid had no effect at all on any of the culture. Sodium hypochlorite, however, could not inhibit the growth of cultures 6, 8, 9, 12 and 13 even at the highest concentrations.

The preservatives polyethylene glycol and ethoidin were found to be totally ineffective, since they could not inhibit any of the cultures at any of the concentrations tried and the results are not shown in the table.

Only three preservatives namely, propyl paraben, methyl-paraben and o-chlorobenzoic acid were tried using broth culture technique. While only four concentrations of preservatives were tried in the plate culture technique, one more higher concentration was included under broth culture technique.

As evident from the results shown in Table 3, propyl-paraben was effective on all the cultures at all levels of concentrations except the first concentration (0.05%). The cultures that were inhibited at 0.05% were *Achromobacter delicatulus* (culture no.2) and *Alcaligenes faecalis* (culture no. 6), which were also inhibited in plate culture studies at the above concentration (Table 2). In effect the results of plate cultures and broth culture techniques were extactly similar.

The results with methyl paraben (Table 4) were almost similar to that obtained with the plate culture technique. Most of the cultures were inhibited at concentrations of 0.2% and above, while at lower concentrations higher percentage of cultures survived.

The effect of o-chlorobenzoic acid (Table 5) on various cultures was as good as that observed with plate culture studies (Table 2). While this preservative was not effective on any of the cultures upto 0.2%, it could prevent the growth of only two cultures (4 and 12) at 0.25% concentration. For testing the effectiveness of preservatives, the agar plate technique was followed, as it was handy, less time consuming and

Table 2. *Effect of chemical preservatives on selected cultures*

Preservative	Propyl paraben %				Methyl paraben %				Ortho-chlorobenzoic acid %				Sodium hypochlorite p.p.m.			
Concn. of preservative	0.5	0.10	0.15	0.20	0.05	0.10	0.15	0.20	0.05	0.10	0.15	0.20	10	15	20	25
Time of incubation h	48 96	48 96	48 96	48 96	48 96	48 96	48 96	48 96	48 96	48 96	48 96	48 96	48 96	48 96	48 96	48 96
Culture number																
1	+ +	— —	— —	— —	+ +	+ +	± ±	— —	+ +	+ +	+ +	+ +	+ +	+ +	± ±	— ±
2	— —	— —	— —	— —	— —	— —	— —	— —	+ +	+ +	— +	+ +	— +	± +	± +	— —
3	+ +	— —	— —	— —	+ +	— —	— —	— —	+ +	+ +	+ +	+ +	± ±	± ±	± ±	± ±
4	+ +	— —	— —	— —	+ +	— +	— —	— —	+ +	+ +	+ +	+ +	± ±	± ±	± ±	± ±
5	+ +	— —	— —	— —	+ +	+ +	+ ±	— —	+ +	+ +	+ +	+ +	+ +	+ ±	± ±	± ±
6	— —	— —	— —	— —	+ +	— —	— —	— —	+ +	+ +	+ +	+ +	+ +	+ +	+ +	+ +
7	+ +	— —	— —	— —	+ +	— —	— —	— —	+ +	+ +	+ +	+ +	± ±	± ±	± ±	± ±
8	+ +	— —	— —	— —	+ +	± +	± +	— —	+ +	+ +	+ +	+ +	+ +	+ +	+ +	+ +
9	+ +	— —	— —	— —	+ +	— ∓	— ∓	— —	+ +	+ +	+ +	+ +	+ +	+ +	+ +	+ +
10	— ∓	— —	— —	— —	+ +	— —	— —	— —	+ +	+ +	— +	+ +	+ +	± +	± +	— —
11	+ +	— —	— —	— —	+ +	— —	— —	— —	+ +	+ +	+ +	+ +	± ±	± ±	± ±	± ±
12	+ +	— —	— —	— —	+ +	± +	— ∓	— —	+ +	+ +	+ +	+ +	+ +	+ +	+ +	+ +
13	+ +	— —	— —	— —	+ +	— +	— —	— —	+ +	+ +	+ +	+ +	+ +	+ +	+ +	+ +

Key: + good growth; — no growth; ± slight growth; ∓ very slight growth. Initial pH 7, all cultures showed good growth in control.

Concentration of sodium hypochlorite is as available chlorine

Table 3. *Effect of propyl paraben on selected cultures**

Concn. of preservative %	0.00			0.05			0.10			0.15			0.20			0.25			pH		
Time of incubation h	24	48	72	24	48	72	24	48	72	24	48	72	24	48	72	24	48	72	24	48	72
Culture number																					
1	20	45	53	20	30	46	20	15	10	20	13	10	20	10	10	23	10	5	7.0	6.5	6.5
2	15	38	43	28	28	15	25	20	15	18	10	15	15	15	15	15	15	10	7.0	6.5	6.5
3	63	83	95	63	40	30	50	40	35	68	60	50	63	40	40	63	45	40	7.0	6.5	6.5
4	30	40	45	35	45	45	35	28	28	35	25	20	35	25	20	35	25	20	7.0	7.0	6.5
5	20	43	55	30	35	40	20	15	13	20	10	15	20	15	15	28	13	0	7.0	7.0	6.5
6	10	28	43	20	20	18	28	23	25	10	10	10	15	15	15	18	8	0	7.0	7.0	7.0
7	45	70	73	60	60	70	53	43	40	65	30	40	40	25	40	43	28	40	7.0	7.0	6.5
8	35	60	65	45	40	43	30	23	20	33	23	25	35	33	28	35	30	28	7.0	7.0	6.5
9	45	88	98	53	63	95	55	48	40	45	40	40	40	28	28	40	35	30	7.0	7.0	6.5
10	43	78	95	43	40	40	40	33	33	43	33	30	43	30	30	43	40	30	6.5	7.0	6.5
11	13	28	40	13	13	15	13	13	10	13	10	10	13	10	10	15	10	8	7.0	7.0	6.5
12	20	43	63	15	18	20	20	13	10	25	15	13	15	13	10	20	13	10	7.0	6.5	6.5
13	14	68	75	35	35	40	40	38	35	40	35	30	30	25	20	50	43	35	6.5	7.0	7.0

*Growth in Klett units

Table 4. *Effect of methyl paraben on selected cultures**

Conc. of preservative %	0.00	0.05	0.10	0.15	0.20	0.25	pH		
Time of incubation h	24 48 72	24 48 72	24 48 72	24 48 72	24 48 72	24 48 72	24	48	72
Culture number									
1	13 30 55	10 28 50	13 28 35	11 23 25	15 15 15	15 15 12	7.0	7.0	7.0
2	23 45 60	45 40 33	33 30 25	20 20 20	23 20 20	28 20 20	7.0	6.5	6.0
3	53 75 103	50 28 25	50 28 20	53 18 10	53 28 10	50 28 8	7.0	7.0	6.5
4	15 43 60	15 18 19	15 18 20	20 10 8	20 10 10	20 8 8	7.0	7.0	6.0
5	10 38 55	5 58 65	10 25 45	10 25 45	13 5 8	13 5 5	7.0	7.0	7.0
6	15 38 63	25 25 25	18 12 10	15 15 15	15 15 13	15 15 13	7.0	7.0	5.5
7	33 68 78	65 78 65	50 50 42	38 32 20	30 22 25	25 25 20	7.0	7.0	6.0
8	10 38 65	35 43 60	18 40 45	10 15 30	17 10 10	35 25 23	6.5	7.0	7.0
9	25 68 85	30 27 55	25 30 37	20 20 29	35 20 33	30 18 17	7.0	7.0	7.0
10	45 78 73	45 55 50	38 41 38	38 38 33	45 45 33	43 30 28	7.0	6.5	5.5
11	10 25 48	18 25 55	20 15 20	20 15 15	17 12 14	15 12 12	7.0	6.5	5.5
12	13 43 68	13 33 53	11 13 45	11 13 18	11 10 8	11 10 5	7.0	7.0	6.5
13	18 38 53	18 30 50	18 35 35	20 20 20	20 15 15	28 23 23	6.5	7.0	7.0

*Growth in Klett units

Table 5. *Effect of Ortho-chlorobenzoic acid on selected cultures**

Concn. of preservative %	0.00			0.05			0.10			0.15			0.20			0.25			pH		
Time of incubation h	24	48	60	24	48	60	24	48	60	24	48	60	24	48	60	24	48	60	24	48	60
Culture number																					
1	18	43	63	20	38	65	18	45	45	18	50	48	30	38	35	20	20	23	7.0	7.0	7.0
2	40	60	60	40	58	60	40	55	58	30	58	63	30	48	58	25	38	35	7.0	7.0	7.0
3	55	83	110	50	75	80	40	65	75	40	70	83	50	73	75	55	75	80	7.0	6.5	6.5
4	25	43	45	25	45	45	20	35	38	25	35	35	25	30	30	25	25	25	7.0	6.5	6.5
5	20	53	60	25	53	48	10	40	38	20	40	38	20	35	28	18	18	23	7.0	6.5	6.5
6	20	45	50	15	35	50	20	38	43	20	40	43	20	35	43	20	20	23	7.0	7.0	7.0
7	40	73	78	40	70	75	45	73	75	50	73	85	45	75	78	45	50	50	7.0	6.5	6.5
8	10	53	60	15	40	55	18	40	48	15	40	45	20	30	33	20	40	33	7.0	6.5	6.5
9	30	55	78	20	58	60	25	65	70	25	60	68	30	68	75	28	45	48	7.0	7.0	7.0
10	45	55	60	40	53	58	35	48	53	40	53	50	45	55	60	45	53	53	7.0	6.5	6.5
11	10	28	35	10	23	48	10	30	35	15	25	28	10	10	18	10	15	20	7.0	7.0	7.0
12	15	40	55	10	40	50	10	48	50	10	45	55	15	45	50	15	15	13	7.0	7.0	7.0
13	25	68	85	30	63	65	30	45	45	35	63	63	38	55	60	38	63	65	7.0	6.5	6.5

*Growth in Klett units

equally efficient as that of other techniques. Also, this method facilitates screening large number of preservatives to various cultures in a short period. However, for comparison, broth culture technique was also done for three of the preservatives which in fact gave similar results as obtained under plate culture.

While the literature on the use of propyl and methyl parabens as preservatives for fish is very scanty, recently Shiralkar (1971) has tried the above preservatives on the cultures isolated from poultry meat for their effectiveness. The results of his study showed that propyl paraben was more effective than methyl paraben to all the cultures tried and there was no difference in the susceptibility of Gram positive and Gram negative bacteria to parabens. In the present study also the results of both plate and broth culture studies are in agreement with the findings of Shiralkar (1971).

The chloro compounds as a class of preservatives have been, generally, found to be either slightly effective or not, in the preservation of fish (Gibbs, 1923; Chen & Fellers 1926; Tarr 1948). These compounds apart from being unstable, generally, bring out undesirable changes in colour and flavour of the meat (Tetsumoto & Yamada, 1950). In the present investigation also, of the two chloro compounds tried, sodium hypochlorite was only marginally effective, whereas o-chlorobenzoic acid was totally ineffective as seen from plate and broth culture studies, in preventing the growth of bacteria belonging to different genera isolated from fish.

The earlier work on ethoidin by Tarr (1946), showed no significant effect in inhibiting the spoilage bacteria of fish when it was incorporated in ice at 0.0067%. Though higher concentrations (upto 0.025%) have been tried in the present study, it appears to be quite ineffective in preventing the growth of these bacteria.

It appears that polyethelene glycol has not been tried earlier as a preservative, although polypropyleneglycol has been tried at different concentrations by Wessells *et al.* (1972). Since propylene glycol could not be obtained in time, polyethylene glycol was tested on the assumption that ethylene moiety may have better effect than propylene moiety. However, it was not found to be of any use at the concentration tried.

The authors wish to thank Professor H.P.C. Shetty, Director of Instruction, College of Fisheries, Mangalore for his interest and also for providing facilities for the work.

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Studies on the Chemical Control of Psychrophilic Bacterial Spoilage of Fish. iv — The Effect of Chemical Preservatives on the Growth of Psychrophilic Bacteria Isolated from Marine Fish

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Dehydroacetic acid and ammonia were found to be very effective in checking the growth of all the cultures at all concentrations tried. The two nitrofuran derivatives namely, semicarbozone and AF-2 were fairly effective, semicarbazone being more effective than AF-2. Sodium nitrite was found to be totally ineffective against all the cultures at all concentrations tried.

The objective of these studies and a review of earlier works by others have already been reported (Anand & Setty, 1977, 1981 a, b). In this paper the results of five more preservatives tried on the various groups of psychrophilic bacteria isolated from fish are reported.

Materials and Methods

The preservatives used were dehydroacetic acid (Sigma), ammonia (BDH),2-(2-furyl) -3- (5-nitro-2-furyl) acrylamide or AF-2 (Ueno Drug Co., Japan), 5-nitro-2-furfurylidene semicarbazone (Koch-Light Laboratories) and sodium nitrite (Sarabai Chemicals, India).

Table 1. *Cultures selected for the study*

Isolate number	Identity
1	*Achromobacter aquamarinus*
2	*Achromobacter delicatulus*
3	*Achromobacter liquefaciens*
4	*Achromobacter superficialis*
5	*Alcaligenes bucheri*
6	*Alcaligenes faecalis*
7	*Flavobacterium diffusum*
8	*Flavobacterium halmephilum*
9	*Pseudomonas fragi*
10	*Pseudomonas* sp.
11	*Micrococcus conglomeratus*
12	*Micrococcus varians*
13	*Vibrio costicolus*

The cultures (Table 1) used in the study were selected from a large number of psychrophilic bacterial cultures isolated from marine fish and identified as belonging to six genera (Anand & Setty, 1977).

The medium used for testing the sensitivity of cultures consisted of glucose 0.1%; bacto-peptone 0.5%; beef extract 0.3%; sodium chloride 3.0%; agar 1.5% prepared in distilled water. The pH of the medium was adjusted to 7.2 and sterilised for 20 min at 1.05 kg/cm² pressure. The chemicals used for the medium were either Difco or BDH make. The plate culture technique is the same as described by Anand & Setty (1981 b)

Results and Discussion

The results of four chemical preservatives are shown in Table 2. Four concentrations of each were selected depending on the nature of the chemical and the concentrations used by earlier workers. The criteria for using the agar plate technique for testing the effectiveness of preservative has been given in the previous paper (Anand & Setty 1981 a).

While the dehydroacetic acid and ammonia (Table 2) were very effective in checking the growth of all the cultures at all concentrations tried, sodium nitrite was totally ineffective at all levels of concentrations. The effectiveness of dehydro-acetic acid

Table 2. *Effect of chemical preservatives on the growth of selected cultures*

Preservative	Dehydroacetic acid				Ammonia				Semicarbazone				AF-2			
Time of incubation h	48 96	48 96	48 96	48 96	48 96	48 96	48 96	48 96	48 96	48 96	48 96	48 96	48 96	48 96	48 96	48 96
Concn. of preservative	0.25%	0.5%	0.75%	1.00%	0.24N	0.58N	1.05N	1.47N	0.05%	0.10%	0.15%	0.20%	0.05%	0.10%	0.15%	0.20%
Culture numbers																
1	— —	— —	— —	— —	— —	— —	— —	— —	— —	— —	— —	— —	+ +	± +	— —	— —
2	— —	— —	— —	— —	— —	— —	— —	— —	— —	— —	— —	— —	+ —	— —	— —	— —
3	— —	— —	— —	— —	— —	— —	— —	— —	— —	— —	— —	— —	± +	— ∓	— ∓	— ∓
4	— —	— —	— —	— —	— —	— —	— —	— —	— ±	— ±	— ±	— ±	+ +	+ +	+ +	± +
5	— —	— —	— —	— —	— —	— —	— —	— —	— +	— —	— —	— —	+ +	± +	— —	— —
6	— —	— —	— —	— —	— —	— —	— —	— —	— —	— —	— —	— —	— —	— —	— —	— —
7	— —	— —	— —	— —	— —	— —	— —	— —	— —	— —	— —	— —	— +	— —	— —	— —
8	— —	— —	— —	— —	— —	— —	— —	— —	— —	— —	— —	— —	— ±	— ±	— ∓	— —
9	— —	— —	— —	— —	— —	— —	— —	— —	— —	— —	— —	— —	+ +	+ +	± +	∓ +
10	— —	— —	— —	— —	— —	— —	— —	— —	— —	— —	— —	— —	— ∓	— —	— —	— —
11	— —	— —	— —	— —	— —	— —	— —	— —	— —	— —	— —	— —	— +	— —	— —	— —
12	— —	— —	— —	— —	— —	— —	— —	— —	— —	— —	— —	— —	+ +	+ +	± +	± +
13	— —	— —	— —	— —	— —	— —	— —	— —	— —	— —	— —	— —	— +	— ±	— ∓	— ∓
Initial pH	6.0	5.0	4.5	4.0	.....10.5.....				.....7.0.....				.....7.0.....			

Note: All cultures showed good growth in 24 h in control plates

Key : + good growth; — no growth; ± slight growth; ∓ very slight growth

and ammonia observed in the present study appears to be mainly a function of their effective pH in the medium. While the dehydroacetic acid reduces the pH of the medium from 6 to 4 depending on the concentrations used, ammonia on the other hand, increases the pH beyond 10.5. Tarr *et al.* (1950) however, found that 0.1 to 0.5% of dehydroacetic acid has no significant effect in inhibiting bacterial spoilage of fish. Ammonia has been tried earlier for preservation of fish by Subramanyan *et al.* (1963) and Mandal & Mukerjee (1974). Though ammonia appears to be a good preservative for storing fish over a period of 3 to 4 months, its use as a commercial preservative is limited, since it can bring about mild changes in texture and flavour of fish meat. In addition to this, the fact that the pH of the fish meat (6.2 to 6.5) is used as a criterion to judge the freshness of fish and use of ammonia for preservation may lead to adulteration of fresh fish with spoiled ones by the traders.

Sodium nitrite has been tried by many workers as a preservative for fish at various concentrations both alone and in combination with sodium chloride with varied results. It has also been conclusively shown to be very effective chiefly at pH 6, but has no effect at pH 7 (Tarr & Sunderland 1940). The negative results observed in the present study may be due to either low concentrations (50–200 p.p.m.) employed or due to the neutral pH provided in the medium. Since sodium nitrite is not allowed for use in foods at concentrations exceeding 200 p.p.m. higher concentrations were not tried in this study and results not shown in Table 2.

The effects of the two nitrofuran derivatives namely, semicarbazone and AF-2 on the growth of various cultures are shown in Table 2. Semicarbazone could inhibit the growth of all the cultures except culture no. 4 at all levels of concentrations tried. AF-2, on the other hand, was not effective at 0.1% level as it could inhibit only 5 out of 15 cultures and even at the highest concentration (0.2%), it could only inhibit 8 cultures. Here again culture no. 4 was not inhibited at all at any concentrations.

Nitrofuran derivatives, in general, according to Japanese investigations are effective against many of the Gram-positive and Gram-negative bacteria and in particular, they are very effective against spore forming bacilli (Obatake, 1965; Matsuda, 1966). However, Obatake & Matsuda (1965) have found that AF-2 and AF-5 had almost the same preservative effect as that of CTC in the preservation of fish. In the present study, though AF-2 was effective at higher concentrations it could not inhibit cultures of *Achromobacter, Pseudomonas, Micrococcus* and *Vibrio* at lower temperatures. However, other nitrofuran derivative namely semicarbazone appears to be a potent preservative for fish, since even the lowest concentration tried could inhibit all the cultures except no. 4 which showed only slight growth at all concentrations.

The authors are thankful to Prof. H.P.C. Shetty, Director of Instruction, College of Fisheries, Mangalore for providing facilities and for his interest in the work.

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NOTES

Prediction of Drained Weight in Canned Prawn under Commercial Conditions

A general formula for the prediction of drained weight of canned prawn processed under laboratory condition has been worked outearlier (Chaudhuri, *et. al.*, 1978). Attempts were made in this communication to modify the general formula to predict the drained weight under commercial conditions of processing particularly blanching, as the moisture content of meat depends on the quantum of heat received during blanching (Govindan, 1975). Except blanching all other variable are same as before.

We know the relation

$$W = B\,(3.8–1.44\,M) \quad \ldots\ldots(1)$$

where,

W = fluctuation of drained weight of processed can over the standard pack

B = concentration of salt in the blanching brine

M = moisture content of meat expressed as g of water/g of dry solid

The change in moisture content of steam blanched meat (Ms) at different concentrations of salt in blanching brine (B) and time of blanching (T) follows a hyperbolic relation which may be represented by the general equation of the form (2) and graphically as in Fig. 1.

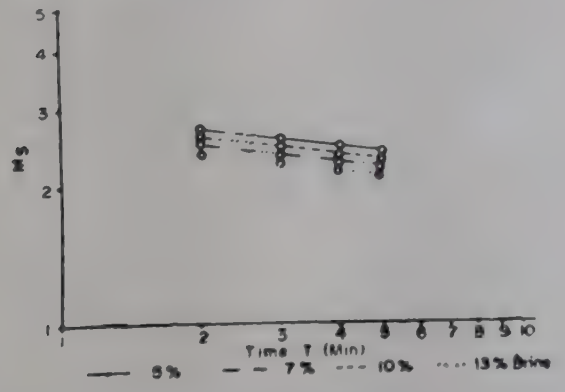

Fig. 1. Change in moisture of blanched meat with time. (Log 'Ms' Vs Log 'T')

$$Ms = aT^b \quad \ldots\ldots(2)$$

where a and b are constants.

'Ms' and 'T' values being known, a and b values were determined by simultaneously solving the equation. The mean values of a and b are given in Table 1.

Table 1. *Mean values of a and b*

Brine concentration % B	Mean values of a	b
5	2.93	–0.125
7	2.88	–0.125
10	2.76	–0.125
15	2.60	–0.125

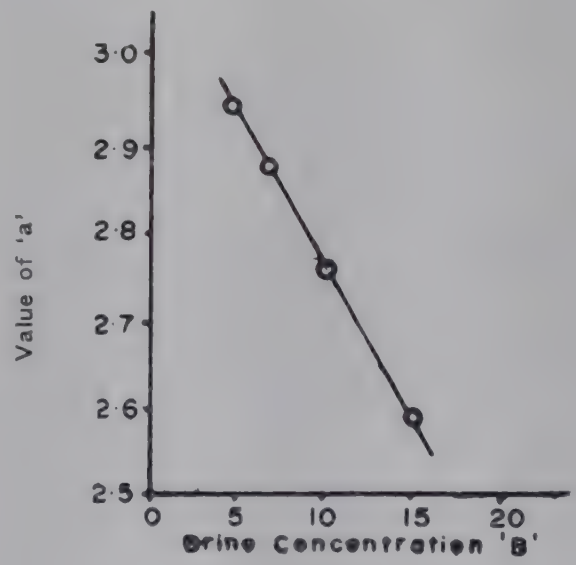

Fig. 2. Plot of 'a' Vs 'B'.

The relation between 'a' and 'B' was obtained by plotting 'a' Vs B (Fig. 2) where

$$a = -0.037B + 3.13 \quad \ldots\ldots(3)$$

Now the equation (2) takes the form

$$Ms = (3.13 - 0.037\ B)\ T^{-0.125} \quad \ldots\ldots (4)$$

Since M = Ms by substituting the value of Ms in equation (1) the following modified form of equation was obtained

$$= (3.8 - [4.507 - 0.0533\ B)\ T^{-0.125}]\ B \quad \ldots\ldots (5)$$

The prediction of drained weight from the equation was found to be accurate within ±5%.

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On the Importance of *Mesopodopsis Zeylanica* (Crustacea, Mysidacea) as Food of Fish

Smith (1879), Tattersall & Tattersall (1951), Stevenson (1958) and Hopkins (1965) have stressed the importance of mysids as food of many marine fishes. Of the estuarine species, *Neomysis awatschensis* is the most extensively studied species. Heubach *et al.* (1963) have shown that it forms an important food of one year old stripped bass *(Roccus sexatilies)* over 2.5 cm in length. From India there is no detailed report regarding the part played by mysids in the food of fishes. Kaliamoorthy (1972) found that *Mesopodopsis orientalis* as an important food of fishes. Devraj *et al.* (1975) reported the presence of mysids in the stomach of pearl spot *(Etroplus suratensis),* but they have not identified the species.

The present investigation was aimed at ascertaining the actual consumers of *Mesopodopsis zeylanica,* to assess its importance in the trophic relationship within the habitat.

Random collection of fishes from Veli lake (08 26′ Lat. N and 76 57′ Long E) was made and their gut contents examined. It was observed (Table 1) that none of the fishes except *Etroplus suratensis* had mysids in their stomach. Further no mysids were found in fishes above 5 cm length. Small fishes measuring 2.5 cm contained 12–27 mysids. Apart from mysids, there were also a good number of copepods. These fishes were observed following swarms of mysids. The stomach of *E. suratensis* was full of *M. zelanica* during February and March, 1973 when a peak in the abundance of this mysid occurred.

This indicated that *M. zeylanica* formed a preferred item in the food of *Etroplus,* particularly juveniles, ranging from 2 to 5 cm. Those above 5 cm showed no preference probably because they fed on larger organisms. The itensity of feeding was observed to be

Table 1. *Gut contents of different fishes*

Fish	No.	Range in total length mm	Gut contents
Mugil cephalus	27	48–361	Diatoms, algae and decayed organic matter
Chanos chanos	14	39–312	Diatoms, blue green algae, filamentous algae and decayed vegetable matter
Channa striatus	19	61–407	Remains of fish, fish fry, insect larvae and mud
Clarius batrachus	23	42–296	Small fish, worms and insects
Glossogobius giures	12	17–128	Hydrilla, filamentous algae, ostracods and insect remains
Arius sp.	8	51–281	Detritus, vegetable matter and remains of small crustaceans
Barbus sp.	31	23–198	Detritus, insect larvae, copepods and mud
Lates calcarifer	6	118–403	Small fishes, prawns and remains of crabs
Etroplus suratensis	58	18–156	Diatoms, filamentous algae, water fleas, mysids and copepods
Etroplus maculatus	32	11– 48	Diatoms and unicellular algae

directly proportional to their abundance in the habitat. This suggests the importance of this mysid in fish culture. If artificial manuring is resorted to, this continuous breeder can be made available in large numbers throughout the year.

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Isolation of *Salmonella larochelle* for the First Time in India

Salmonellosis is one of the most prevalent zoonotic diseases. Despite continuous surviellance and concerted efforts, food poisoning outbreaks due to salmonellae are on the increase particularly in western countries. More than 20,000 cases in man are reported annually in the U.S.A. (Centre for Disease Control, 1976) and 5000 to 6000 incidents in the U.K. (Hobbs, 1973). Food poisoning is not a notifiable disease in many countries and therefore reliable country-wise statistics on the yearly incidence of this infection is not available.

The genus *Salmonella* contains more than 2000 serotypes. In India 122 serotypes are described so far (Saxena *et al.* 1980) and every year new serotypes are being added to the list.

Table 1. *Morphological, biochemical and serological characteristics of Salmonella larochelle*

Morphology	:	Gram negative short rods, motile, no spores
Biochemical characteristics		
Reaction on triple sugar iron agar	:	Acid butt, alkaline slant, gas and hydrogen sulphide produced
Reaction on lysine iron agar slants	:	Purple colour throughout, hydrogen sulphide present
Indole production	:	Absent
Urease production	:	Absent
Fermentation of lactose	:	Negative
Fermentation of sucrose	:	Negative
Fermentation of salicin	:	Negative
Fermentation of dulcitol	:	Acid and gas formed
Serological pattern	:	6, 7; eh: 1,2

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The isolation of a new serotype, *Salmonella larochelle* (6, 7: eh:1, 2), is reported in this communication. This serotype has not so far been reported from any source in this country.

The serotype was isolated on 27th November, 1979 at Bombay from a market sample of frozen froglegs intended for domestic consumption. The method suggested by AOAC (1975) was followed for the detection of *Salmonella*. Two strains isolated from this sample were sent to the National Salmonella and Escherichia Centre at Kasauli for serotyping and were identified as *Salmonella larochelle*. A final report on the identification of this serotype was received on 26th March, 1980. The biochemical properties of *S. larochelle* were similar to that of typical *Salmonella*. (Table 1)

The authors are thankful to the National Salmonella and Escherichia Centre, Central Research Institute, Kasauli for serotyping the strains and Shri. M.R. Nair, Director-in-charge, Central Institute of Fisheries Technology, Cochin for encouragements.

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SYMPOSIUM ON HARVEST AND POST HARVEST TECHNOLOGY OF FISH

NOVEMBER, 1982

Background and Objectives: The ever growing human population and consequent shrinking of land area for food production pose serious problems and man has ventured to the oceans for the much needed protein foods. The declaration of the 320 km economic zone has provided considerable opportunities and has thrown open a great challenge to the maritime nations of the world to explore and exploit its vast potentialities. This necessitates huge financial investment, acquisition of suitable crafts, improved methods of catch, provision of infrastructural facilities at landing centres and development of appropriate technology for the utilization of the landed fish embracing all aspects such as processing, marketing, inspection, quality control etc. The research efforts on the above aspects by the various maritime nations of the world have vastly expanded our knowledge. It is appropriate to pool and discuss at a common forum the advances made, to get an integrated picture of the development and progress in harvest and post harvest technology of fish.

No symposium covering all aspects of fishery technology like capture, processing, distribution etc. and the ancillary fields has been held in the recent past. The IPFC symposium held in Manila in 1978 discussed how the technological advances in one region can be adapted and applied in other situations rather than discussing research results. The objective of the present symposium is to bring together experts and research workers in various aspects of fishery technology like fishing crafts, gear, instrumentation, processing, packaging, inspection and quality control, marketing, education etc. for the purpose of discussing their findings for the common benefit. The symposium is planned to be held synchronising with the silver jubilee celebrations of the Central Institute of Fisheries Technology, the premier institute in India devoted to research and development in all aspects of fishery technology.

Venue: The symposium will be held at Cochin, known for its scenic beauty being set among picturesque lagoons and backwaters. Cochin is the nerve centre of fishing and fish processing activities in the country. Besides being the headquarters of Central Institute of Fisheries Technology, several other fishery institutions like Central Marine Fisheries Research Institute, Integrated Fisheries Project, Central Institute of Fisheries Nautical and Engineering Training, National Institute of Oceanography, Department of Marine Sciences of Cochin University are situated in Cochin.

Date: The symposium will be held for three days late in November, 1982. The actual dates will be announced shortly.

Sponsor: The symposium is organised by the Society of Fisheries Technologists (India).

The symposium will cover both harvest and post harvest technology of fish and will discuss the following aspects of fishery technology.

I HARVEST TECHNOLOGY

1. *Resources:* Marine resources—inshore, offshore, deep sea, Inland resources—rivers, lakes, reservoirs.

2. *Fishing boats*—design aspects, construction materials, building technology, production and maintenance.

3. *Fishing gear and methods*—design concepts, materials, fabrication and rigging, fishing operations and maintenance.

4. *Machinery, equipment and instrumentation*-Marine engines, stern gear and propellers, deck equipment, operation and maintenance, electronic aids/instruments.

II POST HARVEST TECHNOLOGY

1. *Handling, preservation and transportation*—handling on board and afterwards, icing, transport—biochemical and bacteriological aspects of fresh fish spoilage.

2. *Processing and waste utilization*—curing, freezing, canning and non-traditional diversified fish products, byproducts and waste utilization and allied aspects.

3. *Inspection, quality control and marketing* of fresh and processed fish.

4. *Equipment and machinery* in fish handling and processing.

5. *Extension, education and training.*

Registration: The registration fee for the participants from India will be Rs. 25/- per head and US $ 25.00 for participants from abroad. Bonafide members of the society need pay only Rs. 15/-

Language: Language of the symposium will be English.

Papers: Status papers in each discipline will be invited from specialists in the respective fields. Experience papers should contain unpublished research findings and only the papers recommended by a screening committee shall be accepted for the symposium.

The exact date for the conduct of the symposium, the dates by which abstracts of papers as well as full texts of the papers etc. should reach the convener will be notified shortly.

Correspondence: Address all correspondence regarding the symposium to

Convener
"Symposium on Harvest & Post Harvest Technology of Fish"
Society of Fisheries Technologists (India)
Matsyapuri P.O., Cochin-682 029, India

OBITUARY

With deep sorrow we record the very sad and untimely death of Shri G. K. Kuriyan, founder Secretary and the President of the Society of Fisheries Technologists (India) on 4th August, 1980 at New Delhi.

Born at Alleppey, Kerala, on May 24, 1923 Shri Kuriyan had his early schooling at the S. R. V. High School, Ernakulam and his university education at Maharaja's College, Ernakulam; Christian College, Madras and St. John's College, Agra.

He joined the Fisheries Department of the erstwhile Madras State in 1945 as Research Assistant and held the post till 1950. In 1951 he was promoted as Assistant Director of Fisheries. While serving as Assistant Director of Fisheries (Crafts & Tackles) he was nominated by the Government of India in 1956 as counterpart to Dr. H. Miyamoto, FAO Gear Technologist, to formulate a scheme for the establishment of a central institute for fisheries technological research. The Government of India accepted the proposal and in 1957 he relinquished the post of Assistant Director to take up the assignment at the Central Fisheries Technological Research Station, which was subsequently named as the Central Institute of Fisheries Technology. During the early periods of his service he had occasion to work with FAO Gear Technologist Dr. H. Miyamoto, FAO Gear Engineer Mr. G. S. Illugason, FAO Naval Architects M/s. Paul B. Zeiner, Peter Gurtner and K. K. Rasmusson. He also had advanced training in fishing gear and methods at Tokai Regional Fisheries Research Laboratory, Tokyo under Colombo Plan in 1964.

At the time of his death he was the Director of the CIFT, Cochin which post he was holding since 1974. Prior to getting exalted to this onerous assignment, he served as Senior Fishery Scientist-cum-Head of Division (Craft) & Gear) from 1971–1974 and as Senior Research Officer (Craft & Gear) from 1962–1971 and as Assistant Director (Gear) from 1957–1961. Shri Kuriyan was mainly responsible for the development of the mechanised fishing fleet and new concepts in fishing gear designs. He had authored over 75 research/technical papers and guided more than 90 research papers. He was connected with several academic bodies of the Universities of Kerala, Cochin and Calicut; the Central Institute of Fisheries Education, Bombay and Central Institute of Fisheries Nautical & Engineering Training, Cochin. He was an approved guide for the M.Sc. and Ph.D degrees of the Faculty of Marine Sciences of the University of Cochin.

Shri Kuriyan was actively connected with several professional bodies. He was founder Secretary and later was president of the Society of Fisheries Technologists (India); Member, Indian Fisheries Association, Indian Society of Ichthyologists, Appellate Panel of Export Inspection Agency, Advisory Board of the Department of Fisheries, Kerala; Fisheries Research Committees of Kerala and Tamil Nadu, Scientific Panel for Fisheries Research for ICAR, Marine Products Export Development Authority, Cochin; Chairman, Textile Materials for Fishing Purposes Sectional Committee (TDC 42) and Marine Cargo Packaging Divisional Committee (MCPD 21) of the ISI. He was elected fellow of the ISI as outgoing chairman of AFDC 27. He chaired the technical session on "Shellfish" at the International Conference on "Handling, Processing and Marketing of Tropical Fish" at the Tropical Products Institute, London in July, 1976.

The Society of Fisheries Technologists (India) was conceived and organised by him and till his death he took active interest in the affairs of the Society. It was under his able guidance and leadership that the 'All India Symposium on Prawn Fisheries' was conducted at Cochin in 1964 by the Society.

He is survived by his parents and wife.

Shri Kuriyan was a person of pleasing manners and amiable disposition. In his death the science of fishery technology has lost an eminent expert and the Society of Fisheries Technologists (India) its guiding spirit. The Society dips its flag in homage to his highly esteemed and evercherished memory and invokes eternal peace to the departed soul.

OBITUARY

The Society of Fisheries Technologists (India) regrets to announce the sad and sudden demise of Prof. Neelkant Keshav Velankar, one of its founder members, a former member of its Executive Committee (1967–1975) and its Vice President from 1978 to 1980, on 23rd November, 1980 at Bombay.

Shri Velankar took his B.Sc. (Hons.) degree in Chemistry from the University of Madras in 1940 and joined the Indian Institute of Science, Bangalore, as a Research Scholar. He joined the Indian Council of Medical Research in 1945, where he served until he was selected as Assistant Research Officer (Bacteriology) at Central Marine Fisheries Research Institute, Mandapam in 1947. He was promoted as Research Officer (Chemistry) in 1957 and transferred in the same capacity to the Central Institute of Fisheries Technology, Cochin in 1959 on his return from Canada, where he had been on a Colombo Plan deputation for six months. He was appointed as Professor of Fisheries Technology at the Central Institute of Fisheries Education, Bombay, in 1961 and became its Director in 1972.

Prof. Velankar retired from service in 1974 and in July 1976, he was called upon by the University of Cochin to be the Consultant and Head of its newly formed Department of Industrial Fisheries and entrusted with the task of its proper organisation. He relinquished this assignment in June 1978.

Prof. Velankar has carried out extensive research in the field of marine microbiology, fish preservation and biochemistry and is the author of about 40 scientific publications covering these aspects. He has also guided several students for their postgraduate and doctoral research programmes in fish processing technology.

A soft spoken, loving and an extremely refined personality, Prof. Velankar leaves behind him wife, son, daughter and a host of friends and colleagues in the field of his official career and elsewhere to mourn his death.

The Society of Fisheries Technologists (India) dips its flag in honour of one of its close associates and joins the entire scientific ommunity in invoking eternal peace to the departed soul.

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